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The Tanganyika Agricultural Corporation's Farming Settlement Scheme

W. P. Cocking and R. F. Lord

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FOREWORD

Stuart Gillett, C.M.G., Chairman of the Corporation, writes—' I wish to congratulate the joint authors on the comprehensive review they have undertaken of the Farming Settlement Scheme operated by the Tanganyika Agricultural Corporation in Nachingwea, from the time of its inception to the present day, and am confident that the information will be studied with great interest by workers on projects of this nature throughout the Commonwealth. Similar schemes, modified to meet local requirements, are also operated by the Corporation in the other two original " Groundnut " areas at Kongwa and Urambo.

' From the agricultural aspect, both basically and fundamentally, the scheme is sound and provides for a system of land use in which mechanized assistance can be given on a good and tried husbandry basis. Profits to the hard-working and successful farmer are also greatly in excess of what could be earned without such mechanical help. There are, however, still too many failures and thus too many " departures " at the end of each farming season.

' The picture unfolds as the scheme progresses and undoubtedly the largest problem that remains is in the socio-economic sphere. Modifications are continually being made in an endeavour to breach the obvious gaps and thus make the conception of the scheme more attractive. The original intention of a plural society—farmers of different tribes living and working together within the scheme—adds much to the social difficulties encountered and it may well be that future schemes should, wherever possible, be operated on a tribal basis.

' Agreements have in the past been on an annual basis with option to renew. These have now been amended to give security for an indefinite period subject to compliance with the " Farm Regulations ". Insufficient attention has been given to community development and welfare and this is now being rectified as much as possible. The relationship between the Corporation and the farmer has tended to take the form of Employer/Employee rather than that of Landlord/Tenant. The farmer, having received assistance in cash or kind during his first year's residence on the holding and having been obliged to sell all his crops to or through the Corporation, has looked upon his final pay-out rather more as a bonus than as his real farm profit. In an endeavour to establish the correct relationship, vital to

long term success, the advances are now being reduced to a minimum and it is made abundantly clear to the farmer that crops need only be sold to or through the Corporation whilst he is receiving financial assistance. Voluntary thrift is being encouraged in the hope that ultimately the farmer will pay for services as he receives them and then be free to sell his crops at his own volition. Believing, however, that cooperative marketing will prove of benefit to the farmer, the Corporation will continue to encourage the disposal of crops on a cooperative basis.

' Apart from any subsidization which may be considered justified in view of the better land use employed and the increase to the national economy through the resultant increased productivity and wealth, schemes of this nature must be self-supporting. It has been found, however, that whilst this principle is accepted by the farmers and they readily understand the charges levied for direct services, they find difficulty in appreciating the necessity for indirect charges. It has, therefore, been decided to review the whole system of charges in an endeavour to absorb as much as possible into the former, i.e. mechanical operations, etc., and reduce the latter to the minimum.

' Changes will inevitably continue to be required as experience is gained, but if eventually the conception becomes really popular with the farmer and similar schemes spread throughout the country, the effect on the standard of living of the individual and on the national wealth cannot be overstressed. Projects of this nature are always slow to gain momentum and many disappointments occur in the early days. It is hoped that these will be overcome and that similar schemes will be developed in the Territory.'

INTRODUCTION

(a) *History of scheme*

Although in the original conception of the Groundnut Scheme it was envisaged that in due course the African would play an increasingly important part in its operation, it was not until 1952, after the reorganization outlined in *Cmd. 8125* had taken place, that any positive steps in this direction could be taken.

In the preceding years, techniques of land clearing and the cultivation of cash crops using a combination of machinery and hand labour had been developed and it was considered that the knowledge acquired could, with modification, be successfully applied to the task of overcoming the limitations of traditional hoe cultivation, so raising the productivity and hence the standard of living of the African cultivator.

In 1952–3, 28 Africans were selected from a much larger number of applicants to farm holdings under the supervision of a European Manager and in each succeeding year the acreage under cultivation and the number of farmers have increased with fluctuations, until at the present time nearly 100 Africans are farming over 2 400 acres divided into two Farming Units, each having a European Manager.

(b) *Original objectives*

At the outset, it was envisaged that by combining together European technical skill and mechanical equipment with African labour it would be possible, within the period of a few years, to develop a nucleus of African peasant farmers capable of operating holdings large enough to ensure themselves an improved standard of living. There were at this stage many unknown factors, of which one of the more important was the capacity of the African himself and the extent to which he would be prepared to work harder and to take greater risks for a return that might vary considerably and which depended to some extent on circumstances outside his control.

Without doubt, the limited success that has been achieved to date is due, in no small measure, to the fact that machinery has been used to do jobs only when it has been proved that the work is beyond the capacity of the farmer and his family and if calculations have shown that the additional expenditure will result in an adequate return for the farmer.

(c) *Brief resumé of organization of scheme*

An area of land within easy reach of Nachingwea that had originally been cleared and conserved for large scale mechanized farming was selected. The farm was divided into holdings of an average size of 12 to 15 acres and houses erected for the farmers in groups as near as possible to their own holdings. The farm headquarters and the Manager's house were situated centrally and a piped water supply was provided to various focal points (*Figure 1*).

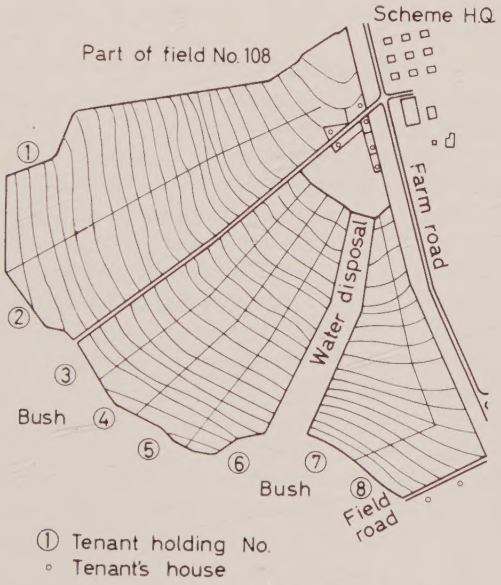

Figure 1. Farming settlement scheme

With the aid of an African Agricultural Assistant, the Manager supervised the carrying out of mechanical operations on the farmers' holdings and

directed them in the timing and methods to be employed in the cultivation of their crops.

The overall management of the scheme was the responsibility of a small committee of Europeans under the chairmanship of the General Manager of the area and inevitably in the first few years, the policy, as originally conceived, was subject to considerable modification in the light of experience. At the beginning of the second year, a Farmers' Advisory Council was set up so that the interchange of ideas and discussion of problems was possible.

A TYPICAL YEAR

(a) *Recruitment of farmers*

In the first year it was considered that by attracting farmers who lived at a considerable distance from Nachingwea, there would be less risk of them leaving their holdings at crucial times during the year to work on their own *shambas* in the villages. Later, however, this was found to be of far less importance than was at first anticipated and, in fact, farmers from nearby villages were often able to call on the help of relatives at busy times.

The normal way of attracting recruits has been to circulate descriptive booklets to District Commissioners in the Southern Province and they in their turn have publicized the scheme at *barazas* throughout the District. It is not easy to explain in print exactly what the scheme has to offer to the industrious African without running the risk of painting too rosy a picture for the less capable individual and for this reason, successful farmers returning to their villages at the end of a season are proving to be more powerful propagandists.

(b) *Housing and welfare*

The importance of good housing and welfare facilities has always been appreciated, but sight has never been lost of the fact that above a minimum standard, any improvement in these services—however desirable it might be—was an additional charge against the production of the land and hence the farmer's profit. Housing has been provided by the Corporation as part of the capital equipment of the land but wherever possible the cost has been kept to a minimum by paying the farmer to build the house in the slack period after harvest is finished. As knowledge of the most suitable size and layout of holdings and the relative fertility of the soil has been acquired, reorganization has become necessary and inevitably some houses have had to be abandoned with consequent waste of money.

Although a building was made available to the farmers for use as a welfare centre, it has not been extensively used other than as a primary school and dispensary. This in part is due to the heterogeneous collection of tribes on the scheme and the long hours worked by the farmers for much of the year and it may be several years before a demand is built up for the 'extra-mural' type of activity.

(c) *Advance in cash and kind*

Few of the Africans coming to the scheme bring with them more than a small amount of food and possibly some hand tools and consequently, in the first year, advances of food and cash are made to them during the season,

being charged at the end of the year against the value of the crops harvested. It is unfortunate that this repayment has to be made in a year when the need for cash is at its greatest and when, due to lack of experience, returns may be less than in succeeding years, and in the light of experience gained, the monthly advances have been reduced from a maximum of *Shs* 60/- to *Shs* 35/- so that although the farmer is forced to live frugally during the year, his cash payment at the end of it is considerably more attractive.

(d) *The season's work on the holding*

With normal rains, the agricultural year begins in December and every effort is made to have farmers established on their holdings well before this time so that they can dispose of any residue from the previous year's crop. Once sufficient rain has fallen, cultivation of the *shambas* with one-way discs is begun in preparation for the planting of groundnuts. All crops are planted on the ridge and wherever possible an interval is allowed between the discing and ridging operations so that a weed kill is obtained, thus easing the burden on the farmer in the first few weeks when he is hard pressed by the need to complete the planting programme and at the same time to weed early sown crops.

Once planting begins, the work continues without a break until late February or early March, the tractors and implements preparing the land whilst the farmers follow up with the hand planting and weeding of the crops. Towards the end of February, the rank growth of grass and weeds often causes difficulty and two discings may be required for the late sown crops.

The shortness of the growing season gives the farmers little respite and in early April harvesting starts with the pulling of groundnuts that generally have been previously dug by machine. Work continues almost without interruption until August or September when the late sown bean crops are picked. With the exception of the digging and decortication of groundnuts, most of the harvesting is done by hand, although in 1955–6, the acreage of groundnuts and soya having been doubled compared with the previous year, it was necessary where farmers had large *shambas* to give them the opportunity of hiring machinery with which to thresh their soya, in order that they could concentrate their attention on the picking of groundnuts.

Once a farmer has harvested and threshed a crop he can then take it to the farm headquarters where, provided that it is a clean sample conforming to the standards laid down, it will be rebagged, weighed and taken into store by the farm Manager for eventual sale by the Corporation on behalf of the farmer.

Very few of the farmers are able to get through the year without hiring labour to help them at busy periods and although sometimes this may reflect a certain innate laziness, there is ample justification for even the most industrious farmer hiring labour if by doing so he is able to cultivate a larger holding and increase his final profit.

(e) *Documentation of transactions*

At the beginning of the season a list is circulated to all farmers detailing the charges that will be made for the various supplies and services that the Corporation will provide during the year (see Appendix I). These charges

fall into three main categories:

(*i*) Mechanical operations, e.g. discing, ridging, decorticating, haulage, etc.

(*ii*) Stores, e.g. seed, fertilizer, hand tools, etc.

(*iii*) Overheads. This is a composite charge which covers the cost of the Manager and farm staff, amortization of the capital cost of the cleared land and its equipment, etc.

At the present stage of development of the scheme, the farmers are allowed credit on all items until the end of the season when the total cost is deducted from the value of their crops before a final cash payment is made to them. At the end of each month the farmer is given details of all debits and credits charged to his account during the month and is thus able to judge his chances of success at the end of the year.

The method of paying for the farmers' crops has varied since the start of the scheme but in the last 2 years a guaranteed price has been agreed between the Corporation and the Farmers' Council so that as soon as a farmer brings crop to the farm headquarters for sale, a priced credit note can be handed to him and once his harvest is complete the cash balance due to him can be paid.

(f) *Marketing of crop*

With a few exceptions, the crops grown on the scheme are the same as those produced on the Corporation's larger mechanized farms and the storage and marketing of them presents no additional problems. Although there would be certain advantages in allowing a farmers' organization to market the crops, the isolation of the area and the relatively small scale of operation would place them at a considerable disadvantage at the present time.

RESULTS OBTAINED BY FARMERS

(a) *Numbers and experience of farmers*

Tables 1 and *2* show that since its inception the scheme has grown steadily

Table 1. Numbers and experience of farmers 1952–3 to 1956–7

Year	Years of experience					Total	Left scheme at end of year
	1	2	3	4	5		
1952–3	28	—	—	—	—	28	16
1953–4	42	12	—	—	—	54	14
1954–5	62	31	9	—	—	102	49
1955–6	68	29	16	8	—	121	60
1956–7	38	27	13	14	7	99	

Table 2. Scheme acreage and holding size

Year	Total scheme acreage	Holding size (acres)		
		Smallest	Average	Largest
1952–3	311	8·3	11·3	23·7*
1953–4	886	8·9	16·4	37·2*
1954–5	1 908	11·3	18·7	28·7
1955–6	2 560†	13·4	21·2	47·6*
1956–7	2 338†	13·8	23·6	48·6*

NOTES: * Double holdings.
† In 1955–6 and 1956–7 there were empty holdings for which suitable farmers could not be found.

until the present year (1956–7) when it was decided, in the light of experience, to increase the average size of holding and regroup the farmers under two Managers instead of three as in the previous year. The rate of turnover of farmers has been disappointingly high in some years, but even so, at the present time over 20 per cent have stayed for at least three years and constitute the nucleus of a more stable community.

In 1952 there was very little guide to the optimum size of holding and it is not surprising that with increase in experience of both farmers and management, the average size of holding is now over twice what it was then.

(b) *Cropping*

Inevitably the choice of crops and rotation (see *Table 3*) has been dependent to a considerable degree on the research carried out by the Corporation's scientists and development work on the large farms. The Africans farming in the locality concentrate almost entirely on the production of long-season sorghum with small areas of groundnuts and simsim as cash crops, but the farmers on the scheme, in order to meet the relatively high level of fixed charges, must be able to spread their labour evenly over a wider range of crops to produce the necessary income. Soya has become of increasing importance and with the development of a variety of groundnut resistant to Rosette disease, it has been possible to increase the income potential of the rotation, at the same time maintaining the balance between legumes and cereals.

Table 3. Proportion of total scheme acreage devoted to main crops 1952–3 to 1956–7

Crop	*1952–3* %	*1953–4* %	*1954–5* %	*1955–6* %	*1956–7* %
Groundnuts	4	11	9	16	17
Soya bean	19	9	7	17	17
Simsim	—	—	6	9	9
Maize/Sorghum	31	16	16	17	16
Sunflower	—	8	8	9	8
Beans and peas	28	41	49	32	33
Other	18	15	5	—	—
	100	100	100	100	100

There is a wide range of opinion concerning the intensity of cropping that can safely be adopted and the need to increase farmers' income has had to be considered in the light of possible long-term effects on soil fertility. The rotation at the present time is as follows:

Year/Break	Crop	Year/Break	Crop
1	Sunflower ($\frac{1}{2}$) / Simsim ($\frac{1}{2}$)	4	Soya bean
2	Groundnuts	5	Sword bean
3	Maize	6	Velvet bean

(c) *Financial results*

Although detailed records are available of the farmers' transactions with the Corporation, their additional outlay for hired labour can at the best only be estimated, and although it is stipulated that all crops must be sold to the Corporation, inevitably a certain unknown proportion finds its way

on to the markets outside the scheme or alternatively is eaten direct from the field. Consequently care must be taken when interpreting the financial results.

A farmer does not receive the whole of his profit in cash as some of it is retained to cover, in the case of the first year farmer, the value of water and food supplied and cash advances made and he himself may elect to retain part of the crop for his own use. Hence the final payment to him is made up as follows:

	Shs	*Shs*
Total income (from crops)	3 500	
Total expenditure (Services etc.)	2 000	
Total profit	1 500	
Less Advances:		
Water	60	
Food	320	
Cash	160	
	540	960
Less Crop retained for own use		360
Cash payment		600

In the second year onwards, the only deduction is for the services, water supplied and crop retained.

Although for comparative purposes the criterion of success must be the total profit or loss, the farmer's outlook will obviously be greatly influenced by the size of the final cash payment.

Table 4. Financial results for four years, per farmer 1952–3 to 1955–6

(Representing average results for one third of the farmers in the medium profit range.)

	1952–3	1953–4	1954–5	1955–6
Number of farmers	9	18	34	40
Acreage of holding	10·0	16·3	18·3	20
	Shs	*Shs*	*Shs*	*Shs*
Income	1 488	3 038	2 307	3 189
Expenditure	457	1 594	1 574	2 043
Total profit	1 031	1 444	733	1 146
Cash payment	379	476	98	499

NOTE: Financial results for 1955–6 are more fully analysed in Appendix II.

In *Table 4* the results obtained by one third of the farmers in the middle of the profit range are shown for each year. In 1952–3, in view of the exploratory nature of the project, the farmers were charged only for the mechanical services and stores used, but in the succeeding years, an additional charge has been made to cover the scheme administration costs. The good results obtained in 1953–4 were due to the high levels of yield and prices (*Tables 5* and *6*), whereas in the following year, the depredations of an insect pest virtually wiped out the crop of pigeon pea planted up on one third of the total acreage.

To appreciate fully the implications of the scheme, it must be realized that at the end of a year, after having worked hard but, at the same time, fed well, a farmer not only has a stock of food for the following year but also over *Shs* 500/- in cash (based on the 1955–6 results). The few estimate

that are available of the cash incomes of Africans outside the scheme suggest a maximum of *Shs* 160/- to *Shs* 200/- per year. Inevitably the range of profits made by the farmers is considerable and it is shown diagrammatically for the 1955–6 year in *Figure 2*. A more detailed analysis of farmers' expenditure and income in 1955–6 is given in Appendix II.

Table 5. Crop yields in lb/acre for 1952–3 to 1955–6

Crop	1952–3	1953–4	1954–5	1955–6
Groundnuts	243	835	801	657
Maize	559	1 021	659	564
Sorghum	632	1 298	—	—
Soya bean	449	559	751	807
Sunflower	—	847	598	547
Simsim	—	—	234	339
Rice	—	239	—	—
Tobacco	211	264	—	—
Cotton	120	245	—	—
Pigeon pea	—	750	157	107
Velvet bean	1 062	854	1 076	644
Sword bean	—	—	879	439

NOTE: The 1952–3 and 1953–4 data relate to results from 1 unit; 1954–5 data to 2 units; 1955–6 to 3 units.

Table 6. Price paid to farmers for crops (E.A. cents per lb)

Crop \ *Year*	1952–3	1953–4	1954–5	1955–6	1956–7
Groundnuts	45·0	59·5	50·9	52·0	44·0
Soya bean	22·0	30·5	28·2	30·0	33·0
Simsim	—	—	53·5	52·0	58·0
Maize	14·0	18·7	18·7	14·0	12·5
Sorghum	26·0	18·7	14·3	—	—
Sunflower	—	27·5	24·4	24·0	25·0
Sword bean	—	—	—	12·0	11·0
Velvet bean	15·0	16·9	13·4	12·0	11·0
Pigeon pea	20·0	19·0	19·6	18·0	18·0

NOTE: The Corporation may have obtained more or less than these prices when the crop was finally sold.

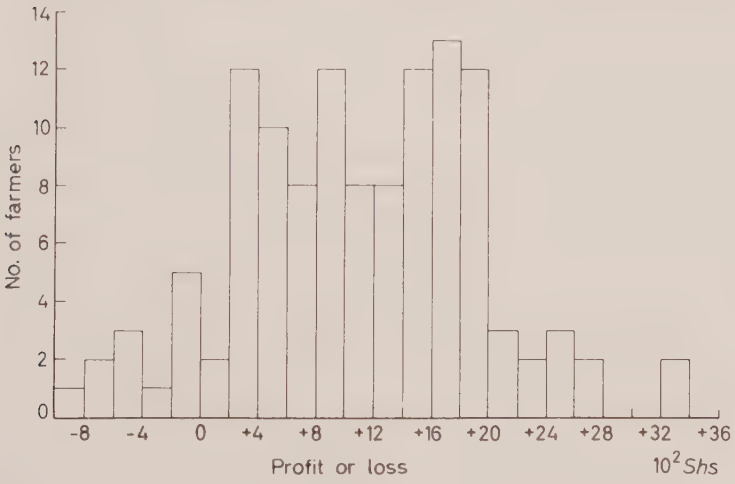

Figure 2. Distribution of farmers' profits and losses 1955–6

OVERALL FINANCIAL IMPLICATIONS OF THE SCHEME

(a) *Need for subsidy in earlier years*

In the previous sections, attention has been directed almost entirely to the operation and results of the scheme as far as the individual farmer is concerned. This may not necessarily be compatible with its overall financial success from the Corporation's point of view and obviously, although a certain element of subsidy may be justifiable in the early years, the scheme as a whole must become a viable economic unit within a reasonable period.

The services provided by the Corporation can be grouped under several main headings:

(*1*) Land and its equipment (including soil conservation)
(*2*) Administration and research
(*3*) Mechanical services
(*4*) Stores, and
(*5*) Crop marketing.

The annual cost of providing these facilities should be met by the various charges made to the farmers, but as all of them, and in particular items *1* and *2*, are in the nature of scheme overheads, unless a disproportionately heavy charge is made in the earlier years, they will not be recouped completely until the scheme is fully developed. At the present time it is considered that one European Manager with a capable African assistant can supervise the operations of farmers on 1 400 acres and it is on this assumption that the calculation of the overhead charge is made (see Appendix III). Items *3*, *4* and *5* do vary to a certain extent in proportion to the area cropped and the number of farmers, but even so, in so far as fixed capital equipment is required to provide these services, there will again be an element of under-recovery in the earlier years.

(b) *Difficulty of assessing charges for services*

Calculation of the rates to be charged, prior to the commencement of the season, is complicated by the fact that it is not possible to foretell with any degree of accuracy the number of farmers that are likely to farm on the scheme (be they old farmers remaining or new farmers) and hence the acreage over which a particular recovery can be made. It can be quite definitely said that, in deciding whether or not to return, a farmer is influenced by more factors than simply the profit or loss that he has made in the preceding year and, indeed, until some of the sociological aspects of the scheme are better understood, forward planning will necessarily be somewhat approximate.

Even though records of machinery operating are available from the Corporation's larger farms, they are not necessarily applicable to the rather different conditions on the smaller farms where, because of the limited range of operations performed, fewer hours are worked by each tractor in the year and where also, more time is lost in travelling between one holding and the next.

(c) *Avoidance of scheme losses*

Losses at the scheme level arise for three main reasons:

(*i*) Recovery rates not high enough

(*ii*) Failure of some farmers to meet commitments
(*iii*) Losses on the final sale of the crop.

Calculation of the rates to be charged to recover all foreseeable costs is difficult enough, but if some farmers, for one reason or another, fail to make sufficient income to cover the charges raised against them, the Corporation will in all probability be left to bear the loss. In some instances, farmers have carried debts forward to a following year and successfully discharged them, but even so a certain proportion of bad debts must be expected.

In offering guaranteed prices to the farmers for their crops, the Corporation assumes the normal risks of a marketing agency and whilst striving to make the scheme as attractive as possible, must protect itself against adverse price trends.

There is much that can be done to reduce the incidence of scheme losses. Careful selection of new farmers is obviously of paramount importance although even a man with a good reputation as a cultivator in his own *shamba* may not necessarily adapt himself to the different conditions of the scheme where undoubtedly the work is harder and is sustained over a longer period of the year. The risk of failures is greatest with first year farmers and as was mentioned above, although advances of cash and food normally prove to be necessary, they are kept as low as possible without impairing the farmer's ability to work because of malnutrition, or preventing him from hiring labour when it is absolutely necessary that he should do so.

Inevitably there will be a wastage of farmers from the scheme, particularly in the first year or so, but as greater continuity is achieved and the risk of farmer failures reduced, a European Manager will be able to supervise more farmers, leading to a reduction in the overhead charge.

Economy in the provision of services and careful calculation of the appropriate recovery rates are both essential to the successful running of the scheme, but it must not be forgotten that ultimately the most important factor is the productivity of the land. When this is increased both the individual farmer and the scheme as a whole must benefit.

PRESENT PROBLEMS

Since 1952 marked progress has been made towards attaining the original objectives outlined, but even so there are still many problems to be overcome.

(a) *High cost of administration*

Due to the fact that the scheme has developed in conjunction with a large-scale farming project, it is not easy to assess the proportion of the area administrative costs that it should bear, particularly in view of the experimental nature of the work. However, it can be seen from *Table 7* that administration at both scheme and area level accounts for over one third of the total costs and, consequently, offers considerable scope for economy in the future. In the first instance, this can be achieved by increasing the area under the supervision of one Manager, and by using African Agricultural Assistants wherever possible, but the eventual aim must be for more experienced farmers to play a larger part in the organization and management of the scheme.

Table 7. Scheme costs per 100 acres—1955–6

		Shs	%
(a)	*Machinery services*	3 076	24
(b)	*Stores*	3 031	23
(c)	*Wages*	1 046	8
(d)	*Amortization charge on land and buildings* ..	1 000	8
(e)	*Scheme administration*	3 739	29
(f)	*Area administration (est. proportion)*	1 000	8
	Total scheme cost	12 892	100

NOTE: Based on data for ' Mchangani ' (Farm 12)—1 300 acres.

Figure 3. A farmer with his wife and children at work on his holding at Nachingwea (by courtesy of Tanganyika Agricultural Corpn)

(b) *Maintenance of fertility*

Although in many parts of tropical Africa complex systems of soil management have been developed by the native cultivators, they have invariably been based on the bush fallow as an instrument of fertility restoration and have required access to a considerable area of land. Obviously the application of similar methods is extremely limited where the cost of clearing and conserving land for cultivation is high.

Little is known about the effect of the various crop rotations on the fertility of the soil where soil conservation is adequate and artificial fertilizers are used. The rotations adopted on the scheme in previous years have been based on the assumption that a certain resting period was necessary, but the leguminous crops grown on the so-called ' planted-fallows ' were in the majority of cases harvested by the farmers, so that in practice little distinction could be drawn between the various breaks of the rotation.

The fallow crops have been unpopular with the farmers not only because of their low value but also because the cultivation of them tended to interfere with work on the cash and food crops, and perhaps most important of all,

to prolong the harvest and hence encroach on the little leisure time left to the farmer and his family once work on the main crops was completed. Nevertheless, they have made a vital contribution to the farmers' income by carrying part of the burden of overhead costs and if they were excluded from the rotation it would be necessary to increase the acreage under the remaining crops. At the present time there is a definite limit to the area of each crop that a farmer can cultivate, and any reorganization along these lines would require the introduction of more mechanical services or hired labour.

Figure 4. Farmers and children herding their cattle on the scheme at Kongwa (by courtesy of the Public Relations Department, Tanganyika)

(c) *Social problems*

In the present year, the 99 farmers are drawn from 6 main tribes in the Southern Province, with representatives of other minor or more distant tribes. To group together all the people from one particular tribe is seldom possible for various technical and administrative reasons and hence a family may find itself living amongst alien people with whom it has little in common.

If to this is added the fairly close supervision essential to the success of the scheme, it is not difficult to appreciate why a farmer's first year is critical from both the social and economic standpoints.

The lot of the womenfolk is seldom improved when they come to the scheme. Traditionally, whilst the man is responsible for the clearing and heavy cultivation of the *shamba*, the woman plays a major part in the planting and weeding of the crop. Whilst mechanical cultivation takes over the

direct responsibility of the man it adds considerably to the burden of the woman and although there is no longer such a distinct division of labour, in certain instances it has led to domestic upheaval and caused otherwise successful farmers to leave the scheme.

Figure 5. The Scheme manager at Urambo instructs his farmers on the principles of flue-cured tobacco culture (by courtesy of the Public Relations Department, Tanganyika)

FUTURE DEVELOPMENTS

In many respects the scheme has now arrived at the cross-roads. In the past five years much has been achieved. A range of reliable crops has been developed and the organization of the scheme placed on a firm footing. Nevertheless, the problems outlined in the previous section have now to be faced. A decision must be reached on the intensity of cropping that can be safely adopted in the future. The choice lies between two extremes. On the one hand, fertility can be maintained entirely by the use of artificial fertilizers, whilst on the other, reliance can be placed on the bush fallow grazed by cattle.

Assuming that the methods are equally efficacious, the financial outcome as far as the farmer is concerned would be approximately the same if the present level of charges could be maintained. With the more extensive method, however, the number of farmers on a given area would be reduced and consequently the cost per farmer of providing the various essential services such as roads, water, workshops, etc. would increase considerably and with it many other administrative costs.

Whatever rotation is finally adopted, every opportunity must be taken to increase the cash income of the farmer. The solution of many sociological

problems lies in the first instance in the technical or economic sphere and the latent desire for an easier life and a better standard of living will only be satisfied when the farmers are receiving an adequate return on their investment.

(*Received December 1957*)

APPENDIX I

CHARGES TO FARMERS FOR SERVICES—1955–6

(1) *Overhead charge*

Shs 4/55 per acre/month on 5/6ths of holding.
(See also Appendix III.)

	Shs	
(2) *Operations*		
Ploughing	30·00	per acre
Discing	10·00	„ „
Ridging	10·00	„ „
Digging	10·00	„ „
Decorticating groundnuts	2·00	„ „
Haulage, crop to railhead and supervisory transport	5·00	„ „
(3) *Advances in cash and kind*		
Cash: interest-free loan to first year farmers—maximum	20·00	per month
Food: sold to first year farmers on credit—maximum	40·00	„ „
(Foodstuffs sold at cost plus handling charges.)		
Water: domestic supply	14·00	per 1 000 gallons
for cattle per head	1·50	per month
(4) *Stores*		
Hand tools, fertilizer, new sacks and other stores available from T.A.C. stocks sold at cost plus handling charge		
Secondhand sacks for use in the field	1·10	per bag
Hire of secondhand sacks per annum or part thereof	0·60	„ „
(5) *Seed* (dressed)		
Groundnuts in shell	26	*cents* per lb
Groundnut kernels	51	„ „ „
Maize grain	19	„ „ „
Sorghum	17	„ „ „
Soya bean	28	„ „ „
Pigeon pea	19	„ „ „
Sunflower	24	„ „ „
Velvet bean/Sword bean	13	„ „ „
Simsim	70	„ „ „
(6) *Stock*	*Shs*	
Cow rent	75·00	per annum
Bull service fee	10·00	per service
(7) *Other services*		
(*a*) When available individual farmers may hire transport from the Farm H.Q.		
(*i*) Individual hire of tractor and trailer	9·00	per hour
(*ii*) Individual hire of Farm Pick-up for journey to and from Nachingwea town	6·00	per trip
(*b*) *Milling maize*		
(*i*) By hand grinder	0·10	per bag
(*ii*) By hammer mill	0·03	per lb

APPENDIX II

ANALYSIS OF FARMERS' EXPENDITURE AND INCOME—1955–6

(All values to nearest E.A. Sh.)

	Low profit group	*Medium profit group*	*High profit group*
Acreage per farmer	19·4	20·0	24·5
INCOME	*Shs*	*Shs*	*Shs*
Groundnuts	769	1 155	1 467
Maize	171	247	434
Soya bean	612	882	1 082
Simsim	239	308	459
Sunflower	171	233	318
Velvet bean, sword bean and others	197	306	396
Sundries and sack refund	32	58	68
Total	2 191	3 189	4 224
EXPENDITURE			
Discing and ploughing	254	271	308
Ridging	169	180	195
Digging (groundnuts)	18	19	26
Threshing	18	17	44
Decorticating (groundnuts)	14	24	29
Haulage from holding to railhead	88	92	104
Labour supplied on repayment	47	8	13
Seed	165	175	187
Fertilizer	27	31	32
Sacks	154	224	285
Small tools	18	21	14
Overhead charge	892	925	1 035
Debts b/f from previous season	94	52	4
Sundries	2	4	8
Total	1 960	2 043	2 284
Total profit	231	1 146	1 940
Crop retained by farmer	118	187	323
Cash profit or loss	113	959	1 617
ADVANCES DURING THE YEAR			
Food	250	257	218
Water	62	63	54
Cash	117	140	125
Total advanced	429	460	397
CASH SETTLEMENT			
Paid	—	499	1 220
Money owing to T.A.C.	316	—	—
FARMERS' EXPERIENCE			
1955–6, i.e. 1 year	25	25	18
1954–5, i.e. 2 years	12	9	8
1953–4, i.e. 3 years	2	4	10
1952–3, i.e. 4 years	2	2	4
No. OF FARMERS per GROUP	41	40	40

APPENDIX III

CALCULATION OF THE CHARGE TO BE RAISED AGAINST EACH FARMER ON A 'PER ACRE' BASIS TO RECOVER THE SCHEME OVERHEAD EXPENSES—1955–6 YEAR

(Based on a fully developed unit with 1 400 acres total but the charge raised only on 1 200 acres, i.e. excl. 1/6th of each holding planted to Pigeon pea.)

	Item	*Annual cost estimate E.A. Shs*
(1)	*Manager's salary and all allowances*	34 000
(2)	*Junior staff wages and allowances (excl. tractor operators)*	12,000
(3)	*Sundry H.Q. expenses and contingencies*	1 500
(4)	*Development costs recovery Shs 10/- per acre/annum*	12 000
(5)	*Government land rent Shs 0·05 per acre/annum*	70
(6)	*Reserve fund Shs 5/- per acre/annum*	6 000
	Total estimated cost per annum	65 570
	Recovery charge per acre/annum *Shs*	54·60

In practice, a monthly charge of *Shs* 4·55 per acre is made.

ANALYSIS OF DEVELOPMENT COSTS

(See 4 above)

	Item	*Cost per acre E.A. Sh.*	
(i)	*Survey work*	4	
(ii)	*Mechanical felling*	35	
(iii)	*Hand clearing and burning*	35	
(iv)	*Root-cutting*	25	
(v)	*Twig picking*	5	
(vi)	*Conservation and roads*	20	
(vii)	*Total cost*	124	
(viii)	*Amortized over 33 years (without interest)*		3·75
(ix)	*Development—water supply*	20	
(x)	*Manager's quarters*	20	
(xi)	*Junior staff quarters*	8	
(xii)	*Farmers' houses*	50	
(xiii)	*Offices and stores*	6	
(xiv)	*Total cost*	104	
(xv)	*Recovered @ 6 per cent p.a.*		6·25
(xvi)	*Item (viii)*	3·75	
(xvii)	*Item (xv)*	6·25	
(xviii)	*Total development recovery rate per acre/annum*	10·00	

The Fula Cattle Owners of Northern Sierra Leone, their Cattle and Methods of Management

A. K. Murray

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TERRAIN

Most of the Fula cattle owners in Sierra Leone reside in Koinadugu District (see *Figure 1*). This district is in the extreme north of the country, lying approximately between latitude 9° and 10° N and longitude 10° 45′ and 12° W. It is on the edge of the African plateau; the level of the valleys varies between 1 500 ft and 1 000 ft. Relatively mountainous, there are numerous hills rising to between 2 500 ft and 3 000 ft, whilst in the south-eastern part of the district lies the massif of the Loma Mountains, topped by Bintimani 6 390 ft, with 9 other peaks over 5 000 ft. The eastern border of the district forms the frontier between Sierra Leone and French Guinea, and follows the watershed between, on the one hand, the Seli and Bagbe rivers flowing south and west out of the district and, on the other, the Niger flowing north and east through French Guinea. Three of the major rivers of Sierra Leone have their headwaters in Koinadugu District; they are, from south to north, the Bagbe, the Seli and the Mongo.

The vegetation is derived Guinea Savannah with fire-resistant tree species (fire climax). Patches of high forest remain at intervals along the river banks and there are also pockets of gallery forest on steep hill sides that have avoided the main bush fires. Main grass species are: *Chasmopodium caudatum*, *Hyparrhenia* spp. *Pennisetum subangustum*, *Andropogon gabonensis*. Tree species include *Parkia*, *Uapaca*, *Daniellia*, *Piliostigma*, *Pterocarpus*, *Lophira*.

CLIMATE

Rainfall varies from 70 in. to 110 in. yearly, being highest in the south-western corner of the District. There is, however, a wide year-to-year fluctuation and at the Animal Husbandry Station, Musaia, where rainfall has been recorded for 7 years, the average is slightly over 80 in. per annum. The maximum recorded annual rainfall is 120 in. and the minimum 63 in. Practically all the rain falls during the period April to November inclusive, with the heaviest rain between July and September. The Harmattan (dry northeast wind) can be expected from December until early February. Bush burning occurs in January, February and March. Temperature variations are between 90° (max.) and 65° (min.) in August, 90° (max.) and 43° (min.) in January, 100° (max.) and 70° (min.) in March*. The humidity is always high except during the Harmattan.

* Data from Animal Husbandry Station records.

INDIGENOUS POPULATION

Three tribes inhabit the District; the Yalunkas in the north astride the Mongo, the Kurankos in the southeast astride the Seli and Bagbe rivers, and the Limbas in the southwest, south of the Mongo and west of the Seli rivers. The Kuranko and Yalunka areas are very sparsely populated, but the population density is higher in the Limba area. The Fula cattle owner is mainly found in Yalunka country (north of the Seli); a few have infiltrated into Kuranko country, and a few are also found in Limba country along the main cattle routes. Fulas are also found in Bombali District, which borders Koinadugu District to the south and west; these do not, however, come within the scope of these notes.

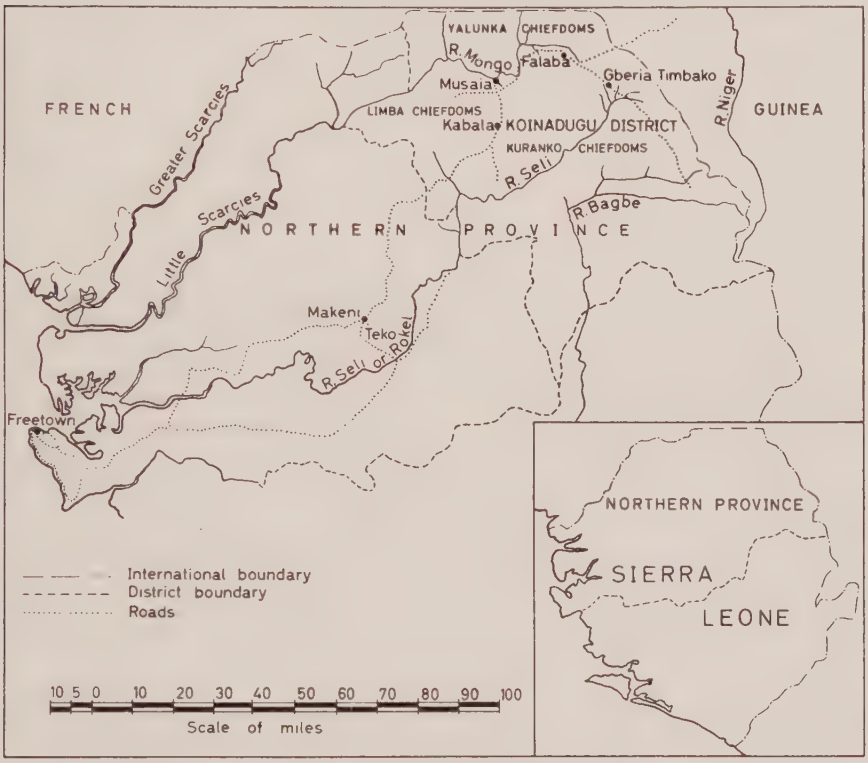

Figure 1

THE CATTLE OWNERS

A detailed history of the Fulas is given by MARTY (1933). Briefly, the main subdivisions of the race are Futa, Teliko, Kebu and Bowai Fulas. All are Mohammedans. The Futa Fulas are not nomadic, whilst the Teliko, Kebu and Bowai Fulas are; this invites comparison with the settled and nomadic Fulani of Northern Nigeria.

Futa Fulas

The name Futa derives from Fouta Jallon in French Guinea. They were known originally as traders in kola nuts, beads, etc., rather than cattle

owners. However, in the course of time they built up herds, starting from a small head of stock. The herd is usually managed by head wives, relatives and servants, who are ex-slaves or their descendants. The Fulas in the Settlement Scheme around Musaia described hereafter are in the main Futas. They are devout Muslims, are well versed in the Koran, and are often literate in Arabic. They are the most progressive element of the Fula tribe and do not display nomadic tendencies to any extent. The Sidiyankas, one of the Fula ruling families, are Futas. It would appear that in the days of the Fouta Jallon Fula empire the Futas were the rulers, religious men, scholars and traders rather than cattlemen.

Teliko Fulas

The Telikos have migrated south from Fouta Jallon. They are large herd owners and also cultivate large upland rice farms. In this district they are mainly found in Sulima Chiefdom, the eastern of the three Yalunka Chiefdoms. Upland rice farms of between 25 and 100 acres have been seen in the Gberia Timbako region. Local Yalunka labour is used for cultivation, sowing and harvesting the crop. Payment for labour is usually made in rice and in this respect the Teliko exploit the hungry season that the improvident Yalunka practically always experiences. After the rice has been harvested, the stubble is subjected to severe over-grazing which leads to soil degradation. When an area has been grazed and cropped bare the Teliko moves on with his herd. The Telikos are as innately conservative and suspicious of change as are cattlemen the world over. They do not mix or intermarry with other Fulas.

Kebu and Bowai Fulas

The Kebus and Bowais have migrated through Fouta Jallon from the Diwal District of Kebou. They are found throughout Northern Sierra Leone and are generally considered to be better cattlemen than either the Futas or the Telikos. This is purely a local tradition and whilst it may be reasonably accurate, there is no evidence to support it, and their methods are not radically in advance of those of the Telikos. They mix freely with Futa Fulas. They do not practise arable farming to any extent.

HISTORICAL BACKGROUND

The main concentration of Fulas in the District is in the three Yalunka Chiefdoms, so these introductory remarks can be concluded by briefly surveying the history of the relationship between the two tribes.

It would appear that in the seventeenth century the Fula and Yalunka tribes lived in the Fouta Jallon area, the Yalunkas being slaves of the Fulas. The Yalunkas revolted and were driven southwards by the Futas in successive wars until they reached the present border region of Sierra Leone and French Guinea at the end of the eighteenth century. This area was at that time virtually uninhabited. They then settled and fortified themselves in a series of large villages. The fortifications originally consisted of a stockade with a rough trench system and gave rise to the rings of cotton trees that at present surround most important Yalunka towns. The Fulas again attacked but for the time being were driven off. At the end of the

nineteenth century the first treaties were signed between the British and the local tribes at Koinadugu town, and pacification of the area was undertaken. Since then, the cattle owners, driven by the economic compulsion of finding fresh pastures due to over-grazing in Fouta Jallon, have been infiltrating southwards by peaceful means. This process appears to have accelerated during the last 10 or 20 years. Even so and perhaps understandably, relations between the Yalunkas and the Fulas have never been cordial, and it is only within the last decade, with the appointment of a Fula headman in Koinadugu District of Sierra Leone and the first tentative government-sponsored assistance in the settlement scheme, that the cattlemen have had any sense of security at all. The inter-tribal relationship now seems to be improving, particularly since roads have opened up this country increasingly to outside influences.

The lack of security felt by cattle owners has expressed itself in their tendency to congregate in groups; this has locally aggravated the over-grazing problem, whilst other areas did not support cattle at all. The settlement scheme aims at thinning the herds out to cover a wide area, by providing that security which has hitherto been lacking.

THE SETTLEMENT SCHEME

Since 1952 the Government of Sierra Leone has been investigating the possibilities of persuading the Fulas to settle. At present the scheme is very much in the nature of a pilot scheme and results have so far been encouraging. Hitherto, the Fula cattle owner has in the main been nomadic, moving on from one area to another in search of fresh grazing and water for his cattle. They are not so nomadic as the general conception of, say, the Bedouin Arabs of North Africa, but they tend to move around in groups, staying in one area from two to three years and then moving their camp, returning to the original site after perhaps 15 to 20 years. (The Futas do not display the same nomadic tendencies and tend to settle in one place for much longer periods.) This movement is accompanied by certain undesirable features due principally to overgrazing, which leads to unpalatable grass species and low bush crowding out more desirable grasses; it also leads to the removal of the vegetative cover which in turn leads to erosion. The wandering cattle also damage and eat the crops of the indigenous Yalunkas.

The scheme attempts to combat these evils by settling individual cattlemen in blocks of one square mile each, situated at least a mile from any established town or village. Security of tenure is provided by means of an agreement between the occupier and the Native Administration of the chiefdom concerned. The occupier is allowed unrestricted grazing rights within the block for a period of seven years, with the option of renewing the agreement for a further seven years. At present it is estimated that one such block can support one cow and follower per seven acres, so that an owner with between 90 and 100 cattle is settled in one block. If the number of cattle owned is greater, the owner will be allotted two, three or four blocks as required. Certain rules of good husbandry (e.g. no over-grazing) are laid down and the owner can be evicted if he breaks these rules. It is hoped that the security that the scheme offers will counteract the present tendency of the cattlemen to concentrate, which in turn aggravates the over-grazing locally. It aims

at spreading the cattlemen more evenly over the country, which is sparsely populated and has no problem of land shortage.

When a cattleman has been settled in a block, the boundaries (running north–south and east–west) are marked with concrete beacons every 200 yards and Yemane trees (*Gmelina arborea*). Further improvements are then carried out. The areas are selected with a suitable water supply. Earth bunds with spillways and concrete sluices are built across swamps to provide suitable areas for swamp rice cultivation both above the bund and in the seepage area below it. The water table is raised by impeding the run-off and better grasses (e.g. *Axonopus africanus*) planted on the fringes of the swamps. The swamps also provide dry season grazing and watering. Research is at present in progress to find a suitable grass for undersowing with swamp rice, for dry season stubble grazing. Attempts are also made to establish *Pueraria* and *Stylosanthes* on the uplands as grazing legumes, particularly in areas where over-grazing has already occurred. Economic trees are planted and the occupant is encouraged to build a good house in his block.

The improvements outlined above aim at making the hitherto nomadic cattleman a settled mixed farmer. The problems raised are numerous, and not least of them is the sociological one, how to integrate the settled nomad with the indigenous population without creating friction. Another problem is to persuade him to cultivate the swamp and grow crops. Yet another problem is the question of controlling run-off from catchment areas. Once established, the scheme will have numerous advantages. The distribution of selected bulls from the Animal Husbandry Station for stud purposes; the use of gammatox, phenothiazine and bloodless castrators will be facilitated and veterinary supervision will be simpler.

The scheme has been financed jointly by the Sierra Leone Government and the Koinadugu District Council, but recently came under the aid of a Colonial Development and Welfare grant. The cost of improving a block works out at £100 to £120 over a 4-year period and it is hoped that mechanization, initiated recently, will reduce the cost of bund construction. The occupant pays a rent which is divided between the local landowner, the Native Administration of the chiefdom and Koinadugu District Council.

Work has so far been confined to the Yalunka country; 17 blocks have been occupied south of the Mongo around Musaia and 20 blocks on the watershed between the Mongo and Seli river systems.

So far results have been encouraging. The Fulas, with their innate conservatism, regarded the scheme originally with some suspicion, but are now asking for blocks and the demand will probably outrun supply for a number of years to come.

THE N'DAMA

This dwarf breed of cattle, admirable for local conditions, appears to have been introduced to Sierra Leone by immigrant Fulas and Mandingos. The animals stand 3½ to 4 ft at the withers and weigh 5 to 7 cwt at maturity, which is usually reached in the fourth year. Tolerance to trypanosomiasis and piroplasmosis, together with longevity, dry season thriftiness and the ability to withstand the unhealthy and humid conditions of the wet season are the most valuable characteristics of this breed. There is wide variation

of colour marking and horn size. Fawn is the most usual colour, the depth of colour varying from season to season, while buff, red, dun and black and mixtures are other colours, possibly indicating influence of other breeds. Some authorities claim that colour is related to size, and that black animals are always the smallest. There appears to be no evidence to support this contention. It has also been suggested that milking capacity is related to colour, and DENT (1950) produced data from the cows then at the Animal Husbandry Station to support the contention that black cows are better milkers. It is noteworthy, however, that Fulas do not like black cattle and they are rarely seen in their herds. It is claimed that black cattle are less resistant to disease than buff or fawn cattle; they are also considered to be unlucky.

Horn size shows considerable variation and naturally polled cattle occur. This may be a sex-linked character occurring only in females, as the author has never seen a polled bull. Two distinct strains of N'dama have been identified in French Guinea, a larger plains strain (Maman and elsewhere) and a stockier hill strain (Fouta Jallon). The larger horned animals might be of the plains strain (ROSS and GATES, 1949, quoted in MASON, 1951).

Family unit and head of stock

There is a very wide variation in the average size of a Fula family, also in the head of stock owned by a family. However, as a rough guide, it can be said that the variation is within the following limits: family 6 to 20, head of stock 50 to 150. The head of a family, whilst owning a herd himself, has controlling influence over the herds of relatives and will often run a number of his own cattle in their herds. In the smaller subdivisions of the family, cattle belonging to the younger and poorer relatives are run with those of the *warri* owner. Thus it is seldom that a herd belongs exclusively to one man. (A *warri* is the wooden stockade within which the cattle are herded at night and the head of the family is frequently referred to as the *warri* owner.)

System of controlling the herd

During the dry season when shortage of grazing is the principal factor, the herd is usually fairly widely scattered; they do not all come into the *warri* at night and it is during this period that losses due to the depredations of hyenas and leopards may be expected.

During this season the cattle graze the swamps, and early burning is also practised to bring on the fresh young shoots of grass in March. In spite of this there is a hungry season in February and March and the cattle are normally lean and ' ribby ' during this period.

Local custom on grazing rights during the dry season places the responsibility on the crop farmer to protect his growing crops during this period with a cattle-proof fence. This, in fact, is hardly a custom yet, but is the gist of a measure introduced by the Commissioner, Northern Province, Sierra Leone, some years ago.

In April, when the cattle are in rising condition due to the flush of young grass, they are easier to control and are all brought into the *warri* at night. They are also transferred to graze swamps and adjacent upland areas that

are going to be cropped during the subsequent wet season; the land thus benefits to some extent from the fertilizing action of the cattle. They are kept there until about the middle of June when they are removed to upland and hill areas remote from any cultivation.

During the wet season the cattle are strictly controlled, as it is then the responsibility of the cattle owner to avoid damaging growing crops, and a heavy fine is imposed by the Native Courts on any cattle owner found negligent in this respect during the period June to December inclusive. The cattle lose condition from the end of June onwards during the height of the wet season; this is due to the poor quality of grazing available. In October, however, condition once more improves as the rains slacken off and the cattle normally retain quite good condition until the period in the ensuing dry season when grazing is most scarce. All the cattle are *warri*ed at night during this season and not usually released until midday. This, plus the fact that plenty of grazing is usually available close to the *warri*, ensures that the cattle do not wander too far afield.

*Warri*s vary in size and shape according to the number of cattle they are designed to accommodate. A typical *warri* might be roughly circular in shape, with a close stick fence surrounding it. The diameter would be about 100 ft and it would accommodate 75 to 100 cattle. For cattle owners with larger herds it is customary to build two or more adjacent *warri*s.

Breeding and selection

Methods of breeding and selection of breeding stock in use are crude and inefficient. Breeding is uncontrolled, but in fact most calves are born between November and March. They are kept in the *warri* and the movement of the dams is fairly strictly controlled. The theoretical knowledge of the cattle owners appears, however, to be in advance of practice.

Age

There is no recognized method of determining the age of an animal, whether by dentition or any other method. The cattle owner usually knows the age of his animals through living with them. Roddan (1933) reports that Mandingo dealers are able to determine a cow's age by the rings on the horn. This method does not, however, seem to be generally used now by either owners or dealers.

Selection of bulls

The general practice is for bulls to be selected from good cows, but size, healthiness and condition are other points. In fact the bulls and cows run together at all times and there is no control of breeding either in terms of the bull used or the age of the bull when it is first used for service. Cattle owners recognize that a bull of from 3 to 4 years old is the best breeding animal and surplus male stock is castrated between the ages of 1 and 3 years for fattening.

However, there is no control over services delivered by bulls under the age of 2, which are at times successful. The ratio of bulls to cows appears to be about 1 to 10, although, as Roddan states, the Fulas recommend that one old and one young bull should be run with between 40 and 50 cows.

Castration

The method used is crude and brutal, but extremely effective. Briefly, the animal is thrown, a piece of hard wood is placed under the testicles and spermatic cord, which are then pulverized with another piece of wood until the ligaments are broken and the testicles pulped. The method adopted sets back the animal considerably, and Roddan estimates for at least six months, which seems very probable.

Unwanted males are not castrated as calves, since it is believed that they would probably die. Recently some interest has been shown in the use of bloodless castrators and it is likely that in the course of time this more humane method will be practised generally. A certain amount of skill is necessary to ensure success and at present the lack of skilled and experienced operators is holding up general extension of this method.

Selection of heifers

Breeding females are culled on sterility only. It is recognized that heifers should not be served until $2\frac{1}{2}$ to 3 years old, and in exceptional cases where the development of the animal has been slow, service may be delayed until 5 years of age. It is also recognized that if a heifer is served at under $2\frac{1}{2}$ to 3 years of age it will probably receive a setback from which it will never recover, and remain stunted for the rest of its life. In spite of this no attempt is made to control earlier service, and in fact the sooner the heifer is in calf the better the cattle owner is pleased. It is perhaps surprising in view of this ' laissez-faire ' attitude, that most herds in fact have quite a high percentage of fully developed and healthy cows.

Gestation and heat

The gestation period of 10 lunar months is recognized, but little is known either of signs of heat, duration of heat or the time that elapses between calving and successful service again. A good cow will, however, produce a calf every 12 to 14 months. MacBurney (1946) notes from observation of a comparatively small number of cows that practically no cows come on heat during the day, but nearly always between evening and early morning. On the few occasions when cows did come on heat during the day the weather was cold. The oestrus period is very short, about three hours average (estimate) and frequently not more than one hour. Occasionally when the nights are cold, cows on heat in the evening are found to be still on heat in the morning.

Calving

As no breeding control is practised, calves are born throughout the year. However, most calves appear during the period November to February inclusive, known in Fula as *Dabunda*—the breeding period. From this it would appear that the dry season from January till April is the best time for conception, but in fact on the Animal Husbandry Station where breeding is controlled and bulls run with cows during the rainy season, the rate of conception and calving percentages are higher than in local herds. More rigorous culling, of course, partially explains this. MacBurney (1946) gives data for the Department of Agriculture's old stock farm at Teko, Makeni,

in 1944 showing that 63 per cent of all services in the year occur between January and April inclusive; 9 per cent only occur between June and September inclusive. He adds that in most tropical countries it has been shown that most of the services occur during the dry season. It is difficult to obtain sufficient data to give an accurate calving percentage, and a certain number of abortions do occur, as is noted later. However, 50 to 60 per cent appears probable; this is high in view of the lack of control that the cattle owners exercise.

Number of calves per cow

Here again it is difficult to produce accurate data, but a good cow may produce as many as a dozen calves and longevity is one of the breed characteristics.

Culling

Females are culled for sterility and old age, males by eye. The culls then become the trade animals and are sold for slaughter. Most herds are culled in November and December to reduce numbers before the onset of the dry season.

Provision of salt

Attention is given at certain times of the year to the provision of salt. A circular fence is made 12 to 18 in. high by driving split canes into the ground, angled so that they slope outwards. They are plastered with mud and dung. The diameter of the circle formed varies from 4 to 9 ft. The enclosed ground is puddled with clay until it is impermeable. Salt at the rate of two to three 32 lb bags per 50 animals is then mixed with the soil from the centre of old ant-hills, in the approximate proportion of 10 parts soil to 1 of salt (Roddan, 1933). Occasionally certain herbs are also added. This form of salt lick is known in Fula as *Tupal*. Roddan reports this as being used during the period April to July to increase the cattle resistance to the unhealthy rainy season.

In fact it appears that salt is given in this manner at intervals of two to three months throughout the year, although maximum attention is given before the heavy rains. Reasons for giving salt are stated by Fulas as follows: it increases fertility and milk production, general health is improved, and finally it helps to keep the animals tame during the dry season when they tend to stray in search of pasture. This appears to be one of the sounder aspects of Fula husbandry.

Milking and suckling

The cows are very low yielders (average under 100 gallons per lactation) and conversely the butter fat content is high. A certain amount of milk is drawn off from the cows and used either for direct human consumption, or is made into ghee, locally known as Fula butter, for which there is a limited market. Skim milk is also sold, and the cash from these sales is used to purchase salt, cloth, etc.

Calves are normally kept in the *warri* and allowed to suckle twice a day. When a cow is being milked the calf is first allowed to suckle one side; when it has drawn off about half the milk it is transferred to the other side,

and the remaining milk on the side already sucked by the calf is milked out into a gourd held between the knees of the milker who squats on her heels. The milker is invariably a woman. Occasionally a circular milking stool is used, solid, wooden, about 9 in. high and 2 ft in diameter. The cows are not usually tethered and stand quite quietly whilst being milked.

Normally only the better cows are milked, as low yielders have a full task in rearing their calves. However, calves in smaller herds are often stunted because too much milk is removed from the cows. In such cases the cow will have been milked before the calf is allowed to suckle. The Kebu Fulas appear to be the worst offenders in this respect. As might be expected, the presence of a calf seems to be necessary before N'dama cows will let down their milk, although it does not appear necessary for the calf actually to suckle the cow.

Health

The main epizootic diseases are at present under control and there has not been a serious outbreak of Rinderpest, Contagious Bovine Pleuro-Pneumonia or Blackquarter within the last five years, although both Rinderpest and Pleuro-Pneumonia occur in adjacent territories. Outbreaks of Anthrax occur but never reach epizootic proportions.

About 20 per cent of all pregnant cows abort and it would appear that there is a low grade infection of *Brucella abortus* throughout the breed. The only evidence, however, to support this is the confirmed outbreaks of brucellosis which occurred at the Animal Husbandry Station, Musaia, between 1951 and 1955, and which were controlled by the use of S.19 vaccine. Local cattlemen exercise no control beyond culling for sterility, which may occur after a cow has been infected with *Brucella* or granular vaginitis.

Calves often become heavily infested with worms, whilst infestations of liver fluke also occur during the wet season, particularly if cows have not been moved on to high ground away from the swamps. An animal heavily infested with worms or liver fluke will lose condition and may eventually die of trypanosomiasis. N'damas are very tolerant to trypanosomiasis, but this appears to be related to the general health of the animal. Local cattlemen try to avoid worm infestation by moving their cattle *warris* about and keeping them out of swampy areas during the wet season. There is now also a growing demand for phenothiazine.

In general, the breed is admirably adapted to local conditions, whilst an attempt is made by local cattlemen to minimize the effects of disease by movement of their herds throughout the year.

INTEGRATION OF ARABLE FARMING

Except for the Telikos, the Fula cattleman has never been an extensive arable farmer. However, a fairly general practice is to grow groundnuts, cassava, millet or maize in upland areas previously grazed by the cattle, or in old *warried* areas. Where wet season swamp rice cultivation is attempted then cattle graze the area in April, May and June prior to the cultivation of the swamp and sowing of the rice. Thus, on a limited scale, use is made of the manuring action of the cattle. The present tendency, particularly

among the Fulas in the Musaia area, is for increased swamp cultivation, and one of the aims of the settlement scheme is to encourage settled mixed farming.

Little use is made of N'dama cattle for draught by local cattlemen. No bullock cart has ever been devised or used, and use of oxen for ploughing has only just started on a limited scale among the Fulas, although the use of oxen for ploughing, sponsored by the Department of Agriculture, has been successfully established among Mandingos and Limba tribesmen for about 25 years. It is hoped that with more security and settled conditions they will adopt ox-ploughing on a larger scale. There is no doubt that a mature N'dama ox working in a team of two is a suitable draught animal, if worked in two stretches of three hours a day. It would also appear, from experimental data, that the live weight gain of oxen so employed is at least the equal of that of unemployed oxen.

TRADE CATTLE

Culled cows, mature bulls no longer required for breeding, and mature oxen, are the basis of the trade in cattle. However, other animals, surplus to breeding requirements, are also sold for slaughter. Little attempt is made to purchase store cattle from the Fula owners in Koinadugu District and fatten them nearer the markets. The trade cattle go to the Freetown market, and also to larger centres in the southern and eastern portions of the Protectorate.

To the Fula cattle owner, his cattle are his capital wealth, and the relative wealth of the cattleman is considered in terms of his total head of stock, rather than in the quality of his animals. This is probably true of most cattle owners throughout Africa, and the Fula is probably fortunate that the N'dama is such a suitable breed for the conditions, and that over the whole District there is no acute over-stocking problem, nor is there likely to be in the near future. For this reason, and with the limitations previously indicated, the N'dama is able to develop its full potentiality under range conditions. The Fula is reluctant to sell his cattle and only does so when he is in need of money. This is one of the reasons why it is difficult to get a regular supply of cattle to the main population centres in Sierra Leone, in spite of the rapidly expanding cattle population, which is estimated to have risen in this District alone from 25 000 in 1946 to 100 000 now. The total cattle population for the country is estimated to be about 150 000.

MARKING

Each herd owner has his own distinctive marking pattern, usually put on by slashing with a cutlass or burning with caustic. A few owners use hot iron brands, in which case the brand mark will be stamped on the animal's hindquarters. At present there is no trade in hides, the skin normally being eaten with the meat.

SUMMARY

The presence of Fulas in Sierra Leone is discussed from the geographical, historical and sociological aspects. The N'dama breed of cattle is described and native methods of management considered.

The Fula cattleman is a reasonably good stockman, and many of his practices are based on sound common sense, although his breeding and selection methods are extremely haphazard, and there has been no attempt to exploit the draught potentialities of the breed.

He is fortunate in having a breed of cattle well suited to local conditions, and in that there is no overall over-stocking problem.

He is neither more nor less suspicious of innovations than any other cattleman, and provided that he can be persuaded that a change in method will benefit him, he is usually prepared to try it. In this respect his tendency to congregate for reasons of security is to be deplored, because of local overgrazing, and ultimately he must change his methods of management, as the increase in the cattle population causes increased pressure on the grazing land available. Breed deterioration may ensue if he cannot be convinced that quality is better than quantity.

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The Composition and Digestibility of Some Conserved Fodder Crops for Dry Season Feeding in Ghana

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PART I. NATURAL GRASSLAND HAY

Livestock farming in Ghana is greatly limited by the presence of tsetse fly in the forest and the pressure of arable farming in the overpopulated savannah of the north.

Very broadly Ghana may be divided into rain forest and savannah. The rain forest area covers most of the old Gold Coast Colony and Ashanti. The savannah covers the Northern Territories and an area of coastal savannah consisting largely of the Accra Plains.

In the rain forest areas, cocoa, plantains, pineapples, cassava and citrus flourish, and livestock are confined to a scavenging population of local hens, goats, a few sheep and pigs. On Government stations cattle and sheep can be seen flourishing but these animals are protected by expensive drugs such as antrycide and the anthelmintics against tsetse-borne blood parasites and internal parasites.

The savannah of the north is overpopulated by agrarian peoples for whom the staple diet is obtained by almost continuous yam and cereal cropping, relieved by fallowing only when the soils are exhausted. Leguminous crops such as groundnuts are limited by widespread phosphate deficiency.

Cattle and sheep are to be seen in some numbers in the north where the influence of agricultural officers has made some progress in the introduction or encouragement of livestock as work animals, as providers of dung or as part of a pattern of farming intended to check the wholesale destruction of the already impoverished soils.

In the south the Accra Plains have considerable potential as a cattle rearing area. The main limiting factor is undoubtedly water but the Volta Dam project may make water supplies available in the foreseeable future. Failing a major water conservation project, there is great scope for the construction of small dams to provide water for cattle and small scale irrigation projects. Because of the very difficult nature of the major soil types of the Accra Plains it is unlikely that arable farming will develop on a large scale or constitute an obstacle to a cattle industry.

At present the cattle population of the Accra Plains consists of a number of fairly large herds of somewhat impure West African Shorthorn cattle. These herds are usually owned by absentee cattle owners who employ Fulani

cattlemen from the north. These Fulanis look after the cattle in return for the milk which they sell. Often the Fulanis receive no other remuneration, consequently the young calves are seriously starved of milk and mortality is high.

The cattle appear to be very slow-maturing but this may be due to a number of environmental rather than genetic factors, although no doubt both play their part. The shortage of milk for young calves may well have a serious effect on growth and development. In the dry season the animals may be near to starving due to the shortage of food and water, consequently liveweight gain suffers severe checks and there may even be loss of weight. This already unfavourable environment is aggravated by the practice of keeping cattle shut up in kraals at night and well into the morning, thus reducing the grazing and water-seeking time available to the animals.

Another factor of some importance is the high incidence of external parasites, mainly ticks, which may cause considerable mechanical damage to the external orifices of grazing cattle and certainly reduce the animals' condition.

Clearly under these conditions cattle cannot possibly achieve a sufficient nutrient intake to reach their liveweight increase potential.

There is evidence (Thomas) that where these factors have been removed, bullocks can be raised to slaughter weight in 3·5 to 4·5 years. This is comparable to results generally obtained in temperate climates and compares very favourably with the estimated 5 to 6 years taken by native-raised cattle. It must be pointed out here that these data are estimates made in the absence of records. Growth curve studies under high and low management conditions have now been initiated at Nungua.

Assuming that water supplies are made available, that excessive milk sales and kraaling can be discouraged, and that tick control can become general practice, then the main obstacle in the way of improved livestock production is the shortage of food in the dry season.

Four methods of fodder conservation may be considered to overcome this difficulty; haymaking, grass-drying, silage-making and irrigation.

At the Nungua Agricultural Research Station of the University College of Ghana, situated on the western side of the Accra Plains, some of these methods were examined on the field scale by the Farm Manager.

Haymaking proved impracticable during the rainy season due to the hay becoming mouldy before it could be dried. There was, however, a brief but unreliable period at the end of the rains when hay could be made successfully.

Grass-drying involves a capital outlay which would be uneconomical and impractical in the extensive type of livestock industry and has not been attempted although there may be a future for green crop drying as a source of vitamin and protein-rich concentrate for pigs and poultry.

Silage was made with varying success due to the difficulty of keeping water out of the silage pits during the rainy season, but by very careful siting the Farm Manager was able to make good quality silage from rain-fed cereal crops and cereal–legume mixtures.

Irrigated fodder has so far been confined to millet which gave large yields of very palatable and nutritious fodder. Sugar-cane and rice are now under

investigation and digestion trials with these crops will be carried out in due course.

No estimate of the relative costs of these three latter classes of feed, i.e. hay, silage and irrigated green fodder, has been attempted in this study which describes chemical composition, digestibility and calculated nutritive value.

EXPERIMENTAL PROCEDURE

Chemical composition was estimated by the conventional methods of Henneberg. The detailed procedure for conducting digestion trials has been described elsewhere (WILSON and LANSBURY, 1958). Starch equivalents were calculated from the digestible nutrients by the method of Kellner as modified by Wood in 1927 (see GOODWIN, 1926).

Crates and harness

Wooden digestion crates were made up by native carpenters from local wood, these crates were 7·5 ft by 3·5 ft and were 4·0 ft high. The floors dropped 1 in. to the middle and sloped forward so that urine drained into a spout and could be collected from the front of the cage. Conventional harness and rubber faeces bags were used to collect the faeces.

Animals used

The West African shorthorn cattle used were rather impure animals which undoubtedly had Zebu blood in their ancestry but, because of the lack of records, no definite assessment of their genetic make-up was possible.

All the cattle were between 2·5 and 3·5 years old and weighed between 5 and 6·5 cwt. Daily dry matter intake was fixed at about 3 lb per live hundredweight.

Description of hays used

Two batches of hay were examined; these had been made from natural grassland on the two major contrasting soil types of the farm. These two soil types are roughly typical of most of the Accra Plains although it would be a great over-simplification to say they represented all the soils found. The first batch of hay was made from a paddock on the grey sand or Simpa soil series which overlies acidic granitic gneiss. The weather was hot and dry and the hay was baled from the windrow.

Botanically the hay was dominantly *Schizachynum* sp., *Setaria sphacelata*, *Heteropogon contortus*, *Ctenium newtonii* and *Sporobolus pyramidalis*.

The second batch of hay was made from grassland on the black clay or Akuse soil series which overlies basic schist. The weather was also hot and dry and the hay was baled from the windrow. Botanically the second batch of hay was dominantly *Vetiveria fulvibarbis*, *Brachiaria falcifera* and *Andropogon canaliculatus*. Although there was a period of some weeks between making the two lots of hay, both were at roughly the same stage of growth, the second batch being somewhat more mature.

Both lots of hay appeared past the stage at which hay would be cut in the United Kingdom, having a bleached and fibrous appearance.

When opened after about four months storage the hay had good aroma and was remarkably free from mould, particularly the more dense bales.

Bullocks found both hays very palatable.

RESULTS AND DISCUSSION

From *Tables 1* and *2* it is clear that both hays were more readily digestible than would have been expected from their appearance and crude chemical composition, since in both cases the crude fibre content was far higher than usual for good hay. The crude protein content of both hays is very low and would certainly require supplementation for normal growth and productive feeding purposes.

Table 1

Feed	Crude nutrients %					
	Dry matter	*Crude protein*	*Ether extract*	*N-free extract*	*Crude fibre*	*Ash*
Hay 1	92·4	4·3	0·6	46·5	34·6	6·4
Hay 2	87·7	3·4	0·8	46·8	30·8	5·9

Feed	Digestible nutrients %				*Starch equivalent*	*Nutritive ratio*
	Crude protein	*Ether extract*	*N-free extract*	*Crude fibre*		
Hay 1	2·3	0·2	31·6	26·7	41	18:1
Hay 2	1·1	0·3	27·1	21·3	32	32:1

Table 2. Digestion coefficients

Feed	*No. of animals*	*Dry matter*	*Organic matter*	*Crude protein*
Hay 1	2	67·8	70·1	52·9
Hay 2	3	59·0	62·0	31·1

Feed	*Ether extract*	*N-free extract*	*Crude fibre*
Hay 1	30·0	77·3	67·9
Hay 2	40·8	60·0	69·1

The digestion coefficients in *Table 2* emphasize the high digestibility of the dry matter and organic matter of both hays. The crude protein digestibility is much reduced in the second hay. This is unusual since although the hay has a lower crude protein content, its crude fibre content is also lower and crude protein digestibility usually increases as the crude fibre content decreases. The quantity of fat present in both hays is so small that it is unlikely that the digestion coefficients have any real meaning since fat excretion and laboratory determination errors could cause too great a total error; for this reason it is not proposed to determine the ether extract

separately from soluble carbohydrate in future. In both hays the crude fibre was very readily digested. It can be seen that with the second hay, the digestion coefficient for crude fibre is considerably higher than that for soluble carbohydrate (nitrogen-free extract). This may be partly due to incompletely digested cellulose appearing in the faeces as undigested soluble carbohydrate.

The relatively high digestibility of these two hays would appear to indicate that the West African cattle used in these trials were extremely efficient in dealing with fibrous material; alternatively, carbohydrate may be fixed in more readily digestible forms of ' crude fibre ' than those which normally appear in this arbitrary fraction. Further studies along these lines are at present in progress.

CONCLUSION

The two Accra Plain grassland hays examined had a high energy value in terms of digestible nutrients. While such natural grassland hay may provide adequate energy, it is very low in protein and would require supplementation if growth, reproduction and production of milk or flesh were to be maintained at an optimum level.

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The Vegetative Propagation of Nutmeg (Myristica fragrans) *by Cuttings*

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Nutmeg is a dioecious plant, male and female flowers being borne on separate trees; the female flowers produce fruits from which the nutmeg of commerce is derived. However, the sex of the tree cannot be determined with any degree of certainty until flowering has commenced at 7 to 8 years of age and although some male trees do exhibit bisexuality, producing a few female flowers later in their flowering cycle, these trees are not normally considered to be of any real commercial value.

The normal method of propagation is by seedlings. Deinum (1931) found that on an average 55 per cent of the mature seed was female, 40 per cent male and 5 per cent bisexual (monoecious). Other data for these ratios may be found in the literature but they all show general agreement in that female and male seeds are produced in approximately equal numbers. The normal estate practice is to retain approximately one male for every ten female trees, from which it may be readily seen that much labour is wasted on the cultivation of male trees which are eventually removed. The advantages of a technique of vegetative propagation from selected trees are obvious. Not only would sex be predetermined but selection could be made for high-yielding trees bearing premium-grade fruits and for disease resistance. Earlier bearing may also be expected from vegetatively produced trees.

In 1955, a hurricane destroyed over 90 per cent of the nutmeg trees in Grenada. Rehabilitation by seedling implied that the first crop of nutmegs would be obtained 8 to 10 years later from approximately half the trees which had been planted. It was with this background that investigations were started in order to examine the feasibility of propagating female nutmeg trees by cuttings.

BRIEF HISTORY OF VEGETATIVE PROPAGATION OF NUTMEG

Budding and grafting

Attempts have been made in the past to bud *M. fragrans* on to other specific rootstocks of the genus *Myristica*. Postma (1935) achieved some success with the modified Forkaert method in Indonesia. Twenty six budded plants out of a total of eighty two eventually sprouted; Deinum (1949) reports the progress of these trees. Ochse (private correspondence) using the same method was able to bud *M. fragrans* on to *M. argenta* and he emphasizes that success may be achieved with this method only by using young rootstocks and bud-scions.

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Approach-grafting has been used (Oxley, 1848); and Ridley (1912) also refers to this technique. However, this method is both tedious and expensive and is unlikely to be of commercial value.

Marcottage

A method of aerial layering is illustrated by Macmillan (1954) in which lateral branches are ring-barked and buried in soil, suspended in bamboo pots. Mention is also made of gootee-layering in which ring-barked branches are wrapped in moss, kept permanently damp by watering from bamboo-pots. No data are quoted to illustrate the degree of success of these methods. A small trial with this method showed that roots could be produced by this method, although field establishment was found to be difficult.

Cuttings

During investigations into the vegetative propagation of tropical plants, Cheesman and Spencer (1936) note that a nutmeg cutting was rooted in the Trinidad-type propagating bins and suggest that with further investigations, propagation by cuttings might be a possibility. From Kew (1938), it was reported that heeled cuttings of lateral shoots, under hothouse conditions in a rooting medium of 90 per cent sand and 10 per cent leaf soil, had produced roots. To the best of our knowledge, no further information is available concerning the subsequent history of these plants.

Figure 1. Nutmeg tree produced from a marcot, approximately 20 years old

The prospect of success with these investigations appeared remote although from the literature available it would appear that marcottage would be the best line of approach. This view was confirmed when it was found that an estate had been established under nutmegs in Trinidad some 20 years

ago, using a marcotting method. Most of the trees have since been removed but some trees remain, one of which is illustrated in *Figure 1*. It was thought, however, that marcotting trials could be more adequately undertaken in Grenada, where a type of vegetative shoot which was considered to be suitable for marcotting was more likely to be available than in Trinidad.

Subsequently, a method of marcottage using polythene-covered marcots, adapted for nutmeg from the technique of Evans (1951) was suggested for trial by the Department of Agriculture, Grenada.

Owing to lack of suitable rootstocks of species of *Myristica* other than *fragrans*, the doubtful compatibility of male and female stock and scions of *M. fragrans* and the paucity of material for marcots, work was concentrated on propagation by cuttings.

Little information was available at the outset with respect to the behaviour of nutmeg cuttings in the rooting bins and the first trials were made with the object of determining whether the standard methods of propagation were limiting in one or more factors.

METHODS

Three methods of propagation were available, viz. closed bins, open spray beds and a constant-mist humidifier.

All 3 methods have been adequately described, respectively by Cheesman and Spencer (1936), Evans (1951) and Murray (1953) and no attempt will be made here to describe them in detail. Suffice it to say that each provides a low light intensity coupled with high humidity and provision for an adequate degree of aeration in the rooting medium.

SUMMARY OF RESULTS OF PRELIMINARY INVESTIGATIONS

(a) *Light intensity and temperature*

Adjustments were made in the spacing of the overhead bamboo slats to provide varying light intensities in the closed bins. Finer adjustments were made by increasing the thickness of the domestic cloth covering the bins. Watering was increased where necessary to avoid increase in temperature. At light intensities above 25 per cent, leaf necrosis and abscission were common, being complete within a few days at 50 per cent and 100 per cent light. At light intensities below 20 per cent the cuttings remained healthy but no apparent advantage was gained by departing from the normal propagation practice. It was considered that the Imperal College of Tropical Agriculture bins provided adequate, if not necessarily maximal, light intensity for propagation.

(b) *Humidity*

The three methods of propagation provide essentially similar conditions of humidity but the method of maintaining the humidity differs considerably with attendant specific effects on the plant material and rooting medium. With the open-spray bed considerable leaching of nutrients by free water droplets may be expected to occur; on the other hand chemical inhibitors, possibly inimical to rooting, may also be removed (Spiegel, 1954). The constant-mist humidifier with which a great deal of success has been achieved in the rooting of difficult species gave disappointing results with nutmeg.

The constantly high humidity provides optimal conditions for basal stem rotting and decomposition of the rooting medium.

Roots were in fact induced only on cuttings in the closed bins. This was attributed not so much to the temperature and humidity effects on the cuttings as to the effect of these factors on the behaviour of the rooting medium.

(c) *Rooting media*

A comparison of rooting media, viz. composted sawdust, sand, coconut fibre and a mixture of fibre and sievings, showed that only the last two were satisfactory for nutmeg rooting. The reason lies in the time taken for root induction to take place, a result of the slow activity of the cambial tissues. It was found that roots could not be induced in less than 4 to 6 months and during this time composted sawdust underwent almost complete humification and sand packed into a tightly compressed, poorly aerated mass. On the other hand coconut fibre and sievings retained a loose open texture throughout the rooting process, maintaining adequate aeration at the base of the cutting. This appeared to serve the double purpose of permitting rapid callus healing of the cut surface which in turn prevented invasion of the cutting by fungal or bacterial pathogens. Rapid rotting of the base of the cutting was almost invariably associated with over-watering and/or under-aeration.

At this stage the only hormone treatment was that used by Evans (1951) on cacao and by Spiegel (1954) on vine hybrids to initiate changes in the meristematic tissues of the stem base. Spiegel has shown that the difficulty in rooting certain vine hybrids is associated with an unidentified chemical inhibitor present in the stem. Water leaching was found to remove this inhibitor and root induction took place.

The following treatments were used:

(1) Immersion for 1 hour in water at 7°C
(2) Immersion for 1 hour in water at 40°C
(3) Immersion for $\frac{1}{2}$ hour in water at 50°C
(4) Control for 1 hour in water at ambient temp. (28° to 30°C)
(5) Immersion of the basal ends of the cuttings in a flow of aerated water for 24, 36 and 72 hours.

The results were entirely negative, only 3 of the 12 controls showing root primordia after 16 weeks, although the cuttings from the water treatment at 7°C remained healthy.

Cuttings from the leaching experiments wilted and died within a few days of being placed in the bins.

HORMONE TREATMENTS

Dilute solutions

Indolyl-butyric acid (IBA), naphthalene-acetic acid (NAA) and a mixture (IBA + NAA) in equal proportions were applied as a 24-hour soak. The concentrations used were 20, 60 and 100 mg per litre. The results were again negative, complete leaf abscission and rotting being observed within 9 days. Subsequent modification of the initial treatment to restrict the soaking period to 7 and 16 hours failed to ameliorate the conditions observed.

These experiments confirmed the view that any treatment which subjected the base of the cutting to anaerobiosis, e.g. immersion in water, predisposed the tissues to rotting and therefore rendered hormone application by this method valueless.

CHOICE OF CUTTING MATERIAL

The nature and type of material selected for cuttings is one of the biggest single factors in the successful rooting of difficult species.

Comprehensive trials have been undertaken to examine the potential value of cuttings selected from all parts of the tree and from trees of different ages. The material ranged from hardwood, semi-hardwood and softwood from the old mature canopy to similar types of material selected from physiologically younger branches at the top of the tree. Also included were cuttings from branches induced by wounding, and watershoots.

Figure 2. Branch produced by wounding. The cut end of the parent branch is just visible (bottom centre)

The analysis of these experiments led to the conclusion which is thought to be the most important in these investigations, that cuttings taken from lateral branches from the mature canopy failed to root, or rooted but rarely; however, cuttings from branches which had been induced by wounding or pruning (*Figure 2*), or taken from watershoots, rooted after hormone treatment with about 50 per cent efficiency. The physiological explanation of this phenomenon is difficult to assess but it would suggest that these shoots are exhibiting juvenile characteristics. Similar material from other trees, both temperate and tropical, has been shown capable of root induction whereas cuttings from mature or old branches fail to root.

It is of interest to note at this stage that nutmeg seedlings approximately 6 months of age will regenerate roots within 8 weeks if treated as cuttings by severing the stem above the roots, *Figure 3.* However, at some stage between 6 months and approximately 18 months the ability to root is inhibited.

Figure 3. Seedlings. Adventitious roots on seedlings, 8 weeks after setting in propagating bins

All subsequent experiments were conducted using wound shoot or watershoot cuttings.

Further experiments with hormones using wound shoot and watershoot material

Table 1 illustrates the effect of three concentrations of IBA applied as a quick dip to hardwood and semi-hardwood cuttings taken from wound shoots and watershoot material.

Table 1. Number and percentage of cuttings rooted after 29 weeks (14 cuttings per hormone treatment, 10 cuttings without hormone treatment)

IBA concentration	*Number rooted*	*% rooted*
0·1 g/litre	5	36
0·5 g/litre	10	71
1·0 g/litre	7	50
Control	2	20

Also included in this trial were 18 cuttings taken from lateral branches. None of these had rooted after 29 weeks from setting.

Representative illustrations of rooted nutmegs may be seen in *Figures 4* and *5*.

The nature of the root in *Figure 6* is of interest. Usually a single root approximately $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter appears as a white protuberance

in the callus and growth in length is rapid for about 3 weeks after which increase in length is arrested. Frequently at this stage 2 or 3 smaller roots emerge from the base of the cutting and behave similarly to the first root. No root hairs were observed on examination under a binocular microscope although lenticels were abundantly present as corky protuberances breaking through the epidermis.

Figure 4. Typical rooted nutmeg cutting, 3 weeks after emergence of primary root, shown on the left

Figure 5. Rooted cutting from a wound shoot. The leaves of these shoots are typically obovate when developed under heavy shade

Figure 6. Close-up of the root in Figure 5. The primary root is frequently as thick as the parent stem from which it is derived and always emerges through the callus pad at the base of the cutting

After root induction, the cuttings were transferred to baskets containing a core of sawdust set in potting soil and placed in the humidifier where they were kept for 3 weeks or longer depending on the extent of the original root system.

Re-treatment of base of cuttings with hormone solution

Improvement in rooting efficiency and degree of branching of the rooting system has been achieved on other plants by re-treatment of the cuttings with hormone solution at an appropriate time after setting (Cooper and Went, 1938).

It was found that with the single-dip treatment, the roots rarely produced laterals, unless the root itself was decapitated. It was found that re-dipping the cuttings at 6 to 8 weeks, after callusing had taken place, not only increased the extent of the root system but also induced lateral roots (*Figures 7, 8* and *9*).

Table 2 indicates the number of plants which had rooted at 20 weeks from setting. Fourteen cuttings were set in each treatment and 7 of each were re-dipped in the same hormone concentration. Most of the treated cuttings appear healthy and it may be expected that more cuttings will produce roots with time.

Table 2. Number and percentage of cuttings rooted 20 weeks from setting. 14 cuttings/treatment: 7 from each treatment re-dipped at 8 weeks

IBA concentration	*Number rooted at 20 weeks*		*% rooted of total set*
	Single dip	*Redipped at 8 weeks*	
0·0 g/litre (*Control*)	0	—	0
0·1 g/litre	1	3	28·5
0·5 g/litre	3	4	50
1·0 g/litre	3	2	36
4·0 g/litre + 4·0 g/litre *NAA*	2	4	43
Total	9	13	

CHEMICAL TREATMENTS

Further experiments have been carried out in order to estimate the value of (*a*) sterilizing the rooting medium and (*b*) incorporating a fungicide in the hormone solution; both treatments were designed to prevent early rotting of the stem. Vapam, sodium *n*-methyl dithiocarbonate dihydrate (Stauffer Chemical Coy), was used to sterilize the rooting media. Aretan, an organo-mercury compound, was incorporated with a hormone dip.

Neither of these treatments was found to be of value except that the Vapam did prevent rapid deterioration of the rooting medium. The correct choice of cutting material appears to be the answer to the problem of rotting.

DISCUSSION

Nutmeg may be propagated vegetatively by cuttings, if the correct choice of material and rooting media is made. The cutting material should be

Figure 7. (Left) Rooted cutting treated with second hormone dip; the secondary lateral roots may be clearly seen and a flower bud may be seen indicated by the pencil. (Right) Rooted cutting given single hormone dip. Lateral roots develop very slowly in the absence of the second hormone treatment

Figure 8. As for Figure 7 but showing a more extensive lateral root system

Figure 9. Close-up of root system of Figure 8 (Left) The lenticels may be seen as greyish-white protuberances on the root surface

semi-hardwood or hardwood cuttings 12 to 15 in. long selected either from chupon-like growths or from shoots produced posterior to wounded or pruned branches; the base of the cutting should be approximately $\frac{1}{4}$ in. in diameter. A rooting medium that does not break down rapidly such as coconut fibre mixed with coconut sievings has been found to be satisfactory; an inorganic medium such as vermiculite might be even more suitable. The most effective hormone treatment has been found to be a 0·05 per cent IBA quick dip, repeated at 8 weeks after setting the cuttings. Root induction takes approximately 4 months but the cuttings are not transplanted into baskets until a well branched root system has been formed, which may take a further 3 months. With the correct selection of cutting material a 50 per cent rooting efficiency may be expected.

It is not claimed that the method of propagation suggested provides optimal conditions for root induction but it is sufficiently encouraging to provide a basis for further studies in territories where nutmeg material is more readily available than in Trinidad. Further improvement in propagation efficiency might be expected from more frequent re-treatment in hormone solution at a higher concentration using an inorganic rooting medium such as vermiculite.

With further work, the application as a commercial method seems promising; although the period required for root induction appears lengthy, it is relatively short when compared with the 6 to 8 years required to determine the sex of the seedling tree. Furthermore, once trees have been established from cuttings, propagation from these trees themselves may be more readily executed as has been shown with other difficult rooting species.

SUMMARY

The results of investigations into the vegetative propagation of nutmeg (*Myristica fragrans*) by cuttings are presented.

The important features are:

(*i*) The correct choice of material for propagation. Semi-hardwood or hardwood cuttings from wound shoot or watershoot branches may be used.

(*ii*) A rooting medium which retains a suitable texture for from four to six months; a mixture of coconut fibre and sievings has been used successfully in the Trinidad-type propagating bins.

(*iii*) Two applications of IBA are used; the effect of the second appears to be to promote a branched root system, resulting in easier establishment.

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The Control of Sucker Growth in Virginia Type Tobacco by the Mineral Oil 'Citspray'

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The practice of removing the apical buds of tobacco plants at the time of flowering, technically known as 'topping', is universal. This enables the plant to concentrate its resources on leaf production, with a consequent improvement in quality and yield.

Following topping, the axillary buds begin to grow, if they have not started already, since the inhibiting auxin of the dominant apical bud has been eliminated. As their growth would nullify the effects of topping, their removal, technically known as 'suckering', is carried out. This operation may be done weekly or three to four times.

The performance of topping and suckering by hand is time-consuming and expensive. It occurs at a time when labour is fully employed in harvesting operations, which causes timely suckering to be difficult, if not impossible. In addition it may assist in the spread of disease, especially mosaic, and also may cause mechanical damage to the plants. Furthermore, the tobacco crop is one which demands a high requirement of hand labour and any means of reducing this under present-day conditions of increasing labour costs is attractive to the grower. These factors have therefore stimulated, in recent years, the search for chemical means of control.

Review of Literature

The first attempts at chemical control were directed at imitating the action of the auxin produced by the apical bud which, while the main shoot continued to grow, inhibited the growth of side shoots. Anderson (1948) in the U.S.A. tested various hormones, using lanoline, polyvinyl alcohol and mineral oil as carriers. Though he found that 5 per cent alphanaphthalene acetic acid would control suckering without harm to the plant, subsequently, almost by accident, he showed that the carrier, mineral oil, would inhibit suckering too.

Wilson, Woltz and Scofield (1952) in the U.S.A. made further advances in the use of mineral oils and finally advised the use of oil–water emulsions (50–50) at the rate of $\frac{1}{2}$ teaspoon per plant (about 2 cm^3). This recommendation is in agreement with those made by Hunter (1954) in S. Rhodesia and Reyneke (1955) in S. Africa, though no rate per plant is given by the latter worker. In N. Queensland (C.S.I.R.O., 1954) 70 to 100 per cent control of suckers by the application of 2 to 4 cm^3 of mineral oil is reported.

The difficulty of actual placement of the oil on the topped surface has been alleviated by the production of equipment, similar to secateurs, which

excises the flower head and at the same time places a known quantity of oil at that point (Wilson *et al.*, 1952; C.S.I.R.O., 1952). The oil then drips down the stem and immediately kills the suckers.

Wilson, Woltz and Scofield (1952) report slight damage to the plant with the use of pure oils, but by using oil–water emulsions most damage is obviated. Practically no damage is reported by Hunter (1954), who also shows that neither yield nor quality of the leaf is affected by their use.

Of other substances applied for the control of suckers, the satisfactory effect of coconut oil has been shown by Pal and Kadam (1949) in India and by Wijeratne (1953) in Ceylon. Of greater importance, however, is that of maleic hydrazide. Unlike the oils or oil–water emulsions, this material has to be sprayed on to the plant, where it is readily absorbed and translocated within the plant. Its action in the plant is somewhat complex, but growth is inhibited. Schoene and Hoffman (1949) in the U.S.A. found its action to cause a pronounced but temporary inhibiting effect on plant growth, the duration of which appeared to be directly proportional to the concentration used.

Petersen (1952), carrying out extensive trials with various formulations, found its use satisfactory. He did not discover any effect on yield, quality or burning properties of the leaf, though this is not entirely supported by more recent work (U.S. Dept of Agriculture, 1954).

Calvert (1953) in Australia included maleic hydrazide in his trials and found that spraying the top leaves at a concentration of 0·4 per cent to 0·8 per cent gave excellent control of suckers. This is confirmed by Reyneke (1955) who also showed that it controlled suckers more than 2 in. long, which mineral oils failed to do. Furthermore, it has been shown (Hunter, 1954) that some suckers are missed by the dripping oil, particularly at the base of the plant.

When applying maleic hydrazide a separate topping operation is necessary, whereas the application of oil and topping can be done with a topper in one operation. Furthermore, rain within 12 to 24 hours reduces the effectiveness of maleic hydrazide (Benson, 1954) whereas with oils only 2 to 4 hours rain-free period appears to be necessary (Hunter, 1954). General recommendations from various parts of the world would appear to suggest strongly that mineral oils are preferable to other sucker-inhibiting materials. It is important, however, to know their specifications before comparing one with another.

MATERIALS AND METHODS

Various experiments were conducted by post-graduate students in 1955, 1956 and 1957 comparing the use of maleic hydrazide (M.H. 30), coconut oil, and two light mineral oils, Risella oil 17* and Citspray*, as possible materials for control of suckers. The variety ' Gold Dollar ' was used in all the experiments.

In the first two years difficulty was experienced in the application of the oils, both in amount and actual placement. Similar difficulty has been experienced in S. Rhodesia (Howell, 1957). In 1957, however, application was made with a pair of topping secateurs†.

* Obtainable from Shell Petroleum Co. Ltd, London, England.
† Oil-rite Tobacco Topper obtainable from Oil-Rite Co., P.O. Box 129, High Point, North Carolina, U.S.A.

DISCUSSION

The importance of method of application was the major feature resulting from these experiments. For a new method to be undertaken by a grower, it must be easy and cheap to apply and at the same time effective, without damaging the plant. At this stage, topping secateurs applying an oil emulsion appear to be the answer to the problem. Further, their use is said to cut the labour requirement to one fifth of that needed with hand labour (WILSON, *et al.*, 1952).

During 1955 and 1956 the use of maleic hydrazide at various concentrations was shown to be not as effective in preventing sucker growth as that of the oils. Application of the chemical was found to be more time-consuming than that of the oils. Pure coconut oil and 50 per cent coconut oil in water were shown to damage the tobacco plant considerably, causing death either directly or indirectly through pathogens attacking the damaged areas. 20 to 25 per cent emulsions achieved good control but were not as effective as the light mineral oils. They also tended to damage the plant.

With regard to the control of suckers by the use of oils, the ability of an oil to accomplish this is dependent first on the oil reaching the buds and secondly on killing them. The latter function is performed well by coconut oil and the light mineral oils, but coconut oil, being more viscous, gives less good coverage, even when large amounts of emulsion are applied. Of the two light mineral oils, Risella oil and Citspray, though both were found to be equally good at control, Citspray was chosen for future work in 1957, because of its white colour. It can be seen easily against the green background of the stem and the operator can thus judge much more easily the amount to apply, depending on size of plant.

USE OF CITSPRAY

Two experiments comparing 12·5, 25 and 50 per cent oil–water emulsions at 3 levels of application, 2, 4 and 8 cm^3 per plant showed that the 12 per cent emulsion failed to kill suckers but that the 25 per cent and 50 per cent emulsions did kill them. The 50 per cent emulsion tended to cause a superficial blackening of the stem but did not appear to damage any plant seriously. No damage occurred from the 12·5 and 25 per cent emulsions but they showed a greater tendency to drip or splash than the 50 per cent emulsion, which, being more viscous, ran down the stem. Scorching of leaves and petiole wings occurred with the 25 per cent and 50 per cent emulsions, if the oil was carelessly applied. With plants of the height treated (about 4 ft) 2 cm^3 was sufficient to reach the lower leaf axils and higher applications were wasteful.

In a further trial, heavy rain soon after application washed off the treatments, which all failed to inhibit suckering. This agrees with work reported by HUNTER (1954).

Once it had been confirmed that 2 cm^3 of a 25 per cent emulsion was sufficient to kill sucker growth of an average-sized plant of the variety Gold Dollar, other varieties were tested. These included Dixie Bright 101, Cokers 139, Virginia 45 and Harrison Special. Control of suckers was satisfactory in all cases, though the rate of application had to be adjusted to the size of the plant to ensure that the lowest axils were reached by the oil. For tall

plants therefore two squeezes of the Oil-rite secateurs (4 to 5 cm^3) are necessary as opposed to the more usual one. The oil treatment did not appear to affect either yield or quality of the cured leaf on all varieties as compared with hand suckering (HUNTER, 1954).

SUMMARY

Citspray, a light mineral oil, white in colour, has been shown to be suitable for sucker control on Virginia tobacco and should be applied at the rate of 2 to 4 cm^3 of a 25 per cent oil–water emulsion, the rate depending on the size of the plant. The oil is most economically applied through a pair of secateurs, which top the plant and apply the emulsion at the same time.

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Influence of Transplant Type and Starter Solution on Tomato Yields in Trinidad

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The value of paying careful attention to the environment of young tomato plants, since it affects the subsequent earliness of yield and total yield of the mature plant, has been demonstrated under temperate conditions in England over a period of years, particularly for glasshouse tomatoes. The application of techniques advised by research stations has helped to raise the average yield of glasshouse tomatoes throughout England to over 30 tons per acre, with some growers producing a very much higher yield.

The production of young plants in clay pots, modified in recent years to include soil blocks, peat pots and paper pots, has been particularly developed in the United Kingdom, where glasshouse cultivation of tomatoes dominates the total commercial production of tomatoes in the country. On the other hand most of the tomatoes grown in the U.S.A. are cultivated under field conditions and hence the plants are not given quite such individual care and attention with the result that much lower average yields occur. Plants are generally produced on seedbeds, or fields may even be direct seeded. Yields all over the U.S.A. for fresh market produce over the past 10 years have varied from 3 to 5 tons per acre and for processed tomatoes 7 to 9 tons per acre. It has been shown in various parts of the U.S.A. that where plants are produced in the seedbed, considerable care in their production, transporting and transplanting is essential to obtain high early and total yields.

Under tropical conditions all tomatoes are grown in the field, seedlings normally being raised on open seedbeds and then transplanted although direct field seeding is sometimes done. Very little care and attention is given to the production of seedlings and it is one of the major causes of poor yields. This is particularly so where tomatoes are cultivated by small peasant growers.

The object of this paper is therefore to draw attention to the fact that even under tropical conditions by using improved methods for the production of plants, better results can be ensured.

REVIEW OF LITERATURE

There are two main ways of producing tomato seedlings. In the first seedlings are raised in clay pots or blocks or modifications of these, and are transplanted to the field in a block or ball of soil. It is a very expensive system, applicable particularly to the greenhouse industry. The cost of growing and transporting millions of such plants, which are required for the field production of tomatoes in the U.S.A., would be prohibitive. The second, where seedlings are raised on open seedbeds of varying size, is the method used principally in the U.S.A. and the tropics. Here, seedlings are

transplanted with bare roots. They can be planted more rapidly and economically than plants with soil on their roots, either by hand or machine.

For pot-raised seedlings Lawrence (1950), working at the John Innes Horticultural Institution in England over a number of years, has demonstrated conclusively that the quality of compost used in the pot, the method of handling the seedlings, such as early or late pricking out, the size of pot into which they are pricked out and hence the spacing between plants, all have a profound effect on the mature plant, both in earliness of yield and total yield. In the U.S.A. Casseres (1947) showed that spacing plants in boxes 4 in. × 4 in. as opposed to 2 in. × 2 in., which allowed 32 and 8 in.^{3} of soil per plant respectively, had a considerable effect in increasing early and total yield. This was confirmed by Nylund (1956) in comparing plants grown in 3 in. pots with those grown in boxes 2 in. × 2 in. Romshe (1954) in comparing tomatoes transplanted at various spacings in boxes and in various sizes of container has further demonstrated that higher yields are obtained from plantings at wider spacings and in larger containers.

Porte (1952) has outlined the methods used in the U.S.A. for the production of seedlings in the open, either on small beds where the seed is usually sown in rows 12 to 15 in. apart and the plants are 1 to 2 in. apart in the rows, or on a field scale where the seed is machine drilled in rows 15 to 18 in. apart at the rate of 20 seeds per foot of row. He states that tomato plants, grown in plant bands or blocks of soil, can be transferred and set in the field without disturbing the roots and therefore have considerable advantage over plants ' pulled ' from seedbeds. Despite this, most of the plants in the U.S.A. are grown under seedbed conditions, though as much care as possible is given to these pulled seedlings.

In the tropics, seedlings are produced on open raised seedbeds 2 to 4 ft wide. A small amount of fertilizer or farmyard manure may be added, and the seed sown broadcast or thickly in lines a few inches apart across the bed. In general no thinning is done and the seedlings are seriously overcrowded, and are tall and slender plants with sparse foliage and poor root systems. Such plants when set out are liable to mechanical injury, to early disease and insect attack, wilting and destruction by strong winds and drought. Work and Amy (1950) in Puerto Rico in comparing three grades of seedbed-produced planting material—strong, medium, and poor plants—demonstrated conclusively that better plants not only produce higher yields but need fewer replacements. Apart from this, little work has been done to show the effect of quality of plants on subsequent crop yield in the tropics.

When the seedbed-produced plant is transplanted damage to the roots occurs. The idea of applying a solution of soluble nutrients or starter solution to enable the plant to withstand the shock of transplanting and so become established more quickly came into prominence particularly in the U.S.A. where mechanical transplanters capable of injecting water into the planting hole at transplanting time are used.

Baker (1937) found that on soils low in available phosphorus, the use of soluble phosphate at planting time enabled the plant to grow more quickly, reduced the amount of supplying necessary and brought about earlier fruiting and bigger total yields. Sayre (1938, 1939) virtually confirmed this but used a mixture containing two parts of ammonium phosphate and one part

of potassium nitrate at the rate of 8 lb of the mixture in 50 gallons of water. A quarter pint of the mixture is given to each plant. Slight modification of this is advocated by PORTE (1952) who adds, however, that a starter solution is recommended for plant setting except where fertilizer has been placed directly in the rows before planting. CARR (1956) in Queensland supports this latter view.

PRODUCTION OF TOMATOES IN TRINIDAD

Tomatoes, mainly of indeterminate or staked types, are the most important vegetable crop grown in Trinidad and indeed in the Caribbean area. With great difficulty, they can be grown from May to December, the wet season period in Trinidad. During this period, rainfalls range from 6 to 14 in. per month and the mean monthly minimum night temperatures range from 70° to 72°F. The more usual period of cultivation is during the dry season from December to May, when the monthly rainfalls for the first four months of the year range from $1\frac{1}{2}$ to 3 in. and the mean monthly minimum night temperatures are about 67° to 69°F. A considerable area of tomatoes is grown at this time of year on land producing rice during the wet season, the rice being harvested in November. Other areas, unsuitable for wet-season rice growing, are used for tomato growing during the same period. In those areas there may or may not be a preceding wet season crop.

Generally little or no preparation of the land prior to planting is carried out other than cutting the weed growth or rice stubble to ground level. This cut material may be removed or possibly burnt. Holes are then made with a cutlass or hoe and the tomatoes, often up to three per hole, planted. On flat lands after about 1 to 2 weeks the first ' moulding up ' is done followed by a second, 2 to 3 weeks later, and a third after a further 2 to 3 weeks. The tomatoes would then appear to have been planted originally on a bank about 1·5 to 2·5 ft high rather than on the flat. These operations help to stabilize the plant, since staking is not carried out, and act as a weeding operation at the same time. On hill lands no such moulding up is done.

Seedlings are produced in the open on raised seedbeds 2 to 3 ft wide. The beds are often forked up and broken down to a fine tilth and a small quantity of pen manure added. The seed is broadcast at approximately half an ounce per 16 square feet and is protected for the first few days from sun and birds by coconut leaves or grass placed over the bed and removed when the seed germinates. No further top shade is given. As a result of this heavy seed rate, very poor plants are produced, and these constitute one of the limiting factors in successful tomato production. When lifting for transplanting to the field, about a month from the time of sowing, little soil or root is retained. Indeed many growers actually shake the plants in water to remove all soil. In many instances plants used are far too old and straggly.

Plants are planted out up to three per hole in rows 3·5 to 4 ft apart and 2 ft within the rows. A small amount of farmyard manure is generally placed in each hole. Little fertilizer other than sulphate of ammonia is given to the plants and little or no fungicidal spraying attempted. For these reasons yields are poor and do not exceed 0·5 to 1 lb per plant.

MATERIALS AND METHODS

A series of replicated experiments was carried out by post-graduate students over the years 1953–57. The main aims of these experiments were:

(*1*) To compare different methods of producing seedlings, and their effect on early and total yield of the subsequent crop. In the first two seasons pot-grown seedlings were compared with peasant-grown seedlings and in the final two years a further type of plant was included, being an improved seed-bed-grown seedling;

(*2*) To find out if a soluble fertilizer mixture in the form of a ' starter ' solution, applied at planting time, had any effect on earliness of yield and total yield. This was done during the latter two seasons.

During the first two seasons the determinate, non-staked variety ' Bounty ' was used but because of very bad attacks of Grey Leaf Spot (*Stemphylium solani*), the variety was replaced during the last two seasons by an indeterminate, staked unnamed variety, locally selected. Spacing of the plants during the first season was 4 ft × 2 ft, the second and third seasons 3 ft × 2 ft, and the fourth 3 ft × 1·5 ft. No staking or pruning was given in the first two seasons, but plants were staked but not pruned in the latter two seasons. There was a slight variation in date of planting out from mid-December to mid-January over the four seasons.

During the 1953–54, 1955–56 and 1956–57 seasons no primary cultivation other than cutting the weed growth close to the ground and removing it was given (the local method). During the 1954–55 season primary cultivation in the form of tractor ploughing and harrowing was done. Fertilizers, other than starter solution, were applied round each plant in the first two seasons at the rate of 500 lb/acre 4:7:5 (N: P_2O_5: K_2O) mixture of sulphate of ammonia, superphosphate and muriate of potash, ten days after transplanting and a further similar amount applied six weeks later except in the 1953–54 season. In the second two seasons, fertilizer was applied at the rate of 500 lb/acre 4:8:4 (N: P_2O_5: K_2O) mixture of sulphate of ammonia, triple superphosphate, and sulphate of potash and a further 600 lb/acre six weeks later.

Plants were sprayed with a copper fungicide weekly after planting. When considered necessary, irrigation water was applied through an overhead irrigation system at a rate equivalent to 1 in. of rain per acre per week. This was given before fungicidal spraying. Overall yields during the first two seasons were poor, 2 400 to 2 800 lb/acre, but during the latter two seasons were extremely good, 14 000 to 16 000 lb/acre.

RESULTS

(1) *Production of plants*

As is customary under temperate conditions for pot-produced plants, seed was first sown thickly in boxes containing good humic soil and potted off in 3 in. clay pots (small ' 60s ') about seven days later. This size of pot is commonly used in the United Kingdom and is also made locally. These pricked out seedlings were placed in open-sided greenhouses with approximately 50 per cent light and were planted out in the field about 3 to 3·5 weeks later.

In order to give full expression to the clay-pot system it was first necessary

to evolve an effective potting compost. Basing work done on that of Lawrence and Newell (1952), various composts were tried out and plants measured for height, width and general conformation. The following compost was chosen and was used with slight modifications throughout the series of experiments:

2 parts by volume sandy-silt loam
1 part by volume sand
1 part by volume coconut fibre dust or cocopeat.

To each bushel of the mixture was added:

0·75 oz. hydrated lime
0·75 oz. sulphate of potash
1·5 oz. superphosphate
1 oz. ammonium sulphate.

There was considerable difficulty in obtaining a loam of the consistency recommended by Lawrence and Newell (1952) and instead it was replaced by the topsoil of a sandy-silt loam dug and sifted through a $\frac{1}{4}$ in. sieve, from land which had been under bamboo for 30 years. Washed sea sand consisting of particles between $\frac{1}{8}$ in. and $\frac{1}{12}$ in. in size was used and coconut fibre dust or cocopeat, a by-product of the coir factories and locally available, replaced peat. Like peat, this material is naturally sterile, is able to absorb many times its own weight of water and initially is a standard product of constant composition. Its use is reported from Puerto Rico (Hume, 1949). Ammonium sulphate, though not ideally suitable, was used instead of hoof and horn, except in the 1956–57 experiment, because the latter is not normally available locally. The soil was steam-sterilized only in the 1953–54 season and in the subsequent seasons weekly sprayings with a copper fungicide were applied.

Peasant-type seedlings were produced in exactly the same manner as is done locally.

Producing plants in clay pots, though a thoroughly tried and reliable temperate system, would probably not be taken up by small peasant growers despite its advantages in improving yields because of the high capital cost of clay pots and a greenhouse in which to house them. Hence in the 1955–56 and 1956–57 seasons an improved seedbed system was employed. Seed was sown thinly in drills 3 in. apart on well prepared beds, similar to those produced by the peasant. The seedlings were thinned about 7 to 8 days later to 3 in. apart, so that the plants had the same amount of lateral room as if grown in a 3 in. pot.

(2) *Transplanting and supplying*

Seedlings, one per hole, were transplanted to the field either during the early morning or in the evening, about 4 to 5 weeks after sowing. The peasant seedlings were treated as they would be locally in that no soil and little root was left on the plants. As much care as possible was given to the improved seedlings, particularly in retaining soil around the roots. The pot-grown seedlings were knocked out of their pots in the field. Dieldrex was applied to the planting holes, at the rate of 1·5 gallons to the acre in 70 to 80 gallons of water, before or immediately after planting.

Starter solution was applied immediately after transplanting. Two parts by

weight ammonium phosphate was mixed with one part by weight potassium nitrate and 5 lb of the mixture was dissolved in 100 gallons of water. During the 1955–56 season half a pint of the liquid was given to treated plants and half a pint of water added to the control untreated plants. SAYRE (1939) showed, however, that of three starter solution mixtures containing the same quantity of fertilizer but supplied at different concentrations, that is, $\frac{1}{4}$ pint, $\frac{1}{2}$ pint, and 1 pint of water per plant, the most concentrated solution with the least amount of liquid per plant, that is $\frac{1}{4}$ pint, gave the best results. Not only does this result in a considerable saving in cartage of actual water but also a greater concentration of nutrients is placed in the immediate vicinity of the roots rather than being dispersed over a larger area. Thus, during the 1956–57 season $\frac{1}{2}$ pint of mixture (5 lb in 100 gallons) was compared with $\frac{1}{4}$ pint of mixture (5 lb in 50 gallons). $\frac{1}{4}$ pint of water was given to the untreated plants.

From *Table 1* it can be seen that transplanting success as indicated by subsequent number of necessary replacements bears a direct relationship to the quality of the transplanted material. One of the chief factors governing success in transplanting is availability of water supply to the plant and this is directly dependent upon the amount of root system present on the plant (LOOMIS, 1924). The pot-raised plants possessed the best root system, and little damage was done to the roots during the actual process of transplanting. Whilst the improved plants had also a good root system, inevitably some damage occurred when transplanting since the roots were not held together in a container. The peasant seedlings on the other hand had few roots left on the plants. Due to this fact wilting of the peasant plants occurred for several days after planting out. Wilting was much reduced in the improved plants and was almost absent with the pot plants.

Table 1. Percentage replacements necessary in relation to original stand of plants

Type	*1954*	*1955*	*1956*	*1957*
Pot	6·1	11·0	8·3	6·4
Improved	—	—	12·5	10·1
Peasant	39·0	37·1	16·5	26·9

The effect of the starter solution on the establishment of seedlings (*Table 2*) was variable. Whilst in general there is an improvement, its use for this purpose alone cannot be advocated.

Table 2. Percentage replacements necessary in relation to original stand of plants with and without starter solution

Type	*1956*	*1957*
Pot:		
With starter	6·3	6·1
Without starter	10·2	6·7
Improved:		
With starter	13·1	8·5
Without starter	11·9	13·6
Peasant:		
With starter	10·5	31·7
Without starter	22·4	17·5

It must, however, be borne in mind when comparing these data that they are based on the fact that only one seedling was transplanted per hole. Local small peasant growers transplant up to three plants per hole, a waste of seed and seedbed space in itself, in the hopes of obtaining at least one plant per hole in the final stand.

(3) *Earliness of yield*

The harvesting of tomatoes in Trinidad starts about 50 to 55 days after the transplanting of seedlings to the field.

(a) *Effect of types of plant transplanted on earliness of yield*—The effect of the type of plant transplanted on subsequent earliness of yield has been shown to be extremely marked. This may be a very important factor to commercial growers, where early yield, in general, means higher prices. A comparison of the effect of the pot seedling, the improved seedling and the peasant-grown seedling on earliness of yield over two seasons is shown in *Figure 1.*

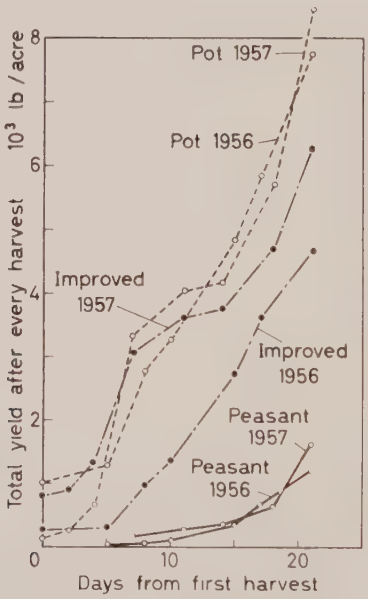

Figure 1. Effect of type of transplant on early yield of plants

It is to be noted that peasant-grown seedlings do not come into yield as early as the pot or the improved seedlings. Furthermore, total yield at 3 weeks after the first harvest for the pot and the improved seedlings is over 5 and 3 times the yield of the peasant seedlings respectively. There is no doubt that this effect is due principally to the fact that the pot-grown plants have little or no check in growth at transplanting and growth is continuous, whereas with peasant-grown seedlings there is a marked check on growth and the plant has virtually to form a new root system before further top growth occurs. Plants of the improved type are intermediate in yield between the two, due to the fact that some damage is caused to them and growth is checked to a limited extent.

(b) *Effect of application of starter solution on earliness of yield*—Applying a small amount of starter solution at planting time does not have such a marked effect on earliness of yield as does the type of plant that is transplanted. A comparison of the effect of giving half a pint of starter solution to plants compared with giving no starter solution over two seasons is shown in *Figure 2*.

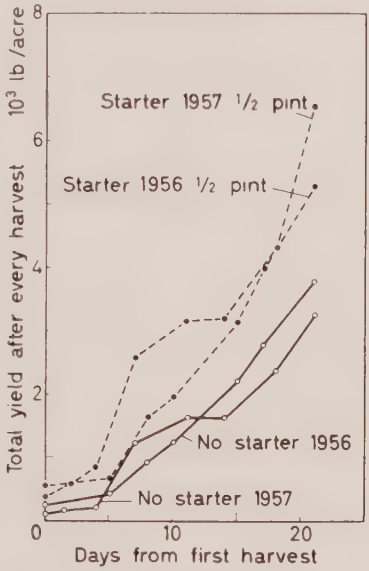

Figure 2. Effect of starter solution on early yield of plants

It is to be noted that the overall increase of yield at three weeks after the first harvest by using starter solution varies from 25 to 100 per cent. There was very little or no difference up to the 3-week period between the yields of plants given a quarter or a half pint of solution as shown in the 1956–57 season and hence the curves were the same.

(4) *Total yield of fruit*

Fruit was harvested when full green or slightly pink and no grading or selection was done. Details are given for total yields of fruit.

(a) *Effect of type of plant on total yield of fruit*—During the 1954 and 1955 seasons yields were poor when the variety grown was the non-staked, determinate variety 'Bounty'. From *Table 3* it can be seen that the yield of plants originally grown in pots is 2 to 3 times that of plants originally produced on seedbeds by the local method. In both cases the results when analysed were very significant. Yields were reduced considerably by the advent of Grey Leaf Spot (*Stemphylium solani*) first reported in Trinidad in 1954, despite weekly spraying.

During the 1955–56 and 1956–57 seasons, yields were extremely good, when the variety grown was a staked, indeterminate locally selected variety whose resistance to disease was reasonably good. The increase of yield of

the pot plants over the peasant plants was approximately 8 000 lb and 4 000 lb per acre in the respective years and in both cases the results when analysed were significant. On the other hand the yields of the improved plants were approximately half way between those of the pot and the peasant types. They were 4 743 lb and 1 921 lb per acre better than those of the latter.

Table 3. Effect of type of plant on total yield of fruit. Yield in lb/acre

Type	*1954*	*1955*	*1956*	*1957*
Pot	3 908	3 171	17 998	18 123
Peasant	1 673	1 545	9 988	14 027
Improved	—	—	14 731	15 948

(b) *Effect of starter solution on total yield of fruit*—The application of starter solution in the 1955–56 season was made when the ground was extremely wet and rainfall was heavy around the transplanting time. Despite this, not only has its application produced an earlier yield but also an increase in total yield of nearly 2 500 lb over the control untreated plants (*Table 4*). In the 1956–57 season both the $\frac{1}{4}$ and $\frac{1}{2}$ pint applications showed similar increases in early yield, but the $\frac{1}{4}$ pint applications gradually drew away until the final yield was about 2 500 lb greater than the control untreated plants and 1 200 lb more than the plants with the $\frac{1}{2}$ pint application. There was no significant difference on analysis between the $\frac{1}{4}$ and $\frac{1}{2}$ pint applications, but both were significant over the untreated plants.

Table 4. Effect of starter solution on total yield of fruit. Yield in lb/acre

Type	*1956*	*1957*
No starter	13 021	14 755
¼ pint	—	17 276
½ pint	15 456	16 068

DISCUSSION

The value of paying careful attention to detail in the raising of tomato seedlings and their subsequent transplanting has been clearly demonstrated under Trinidad conditions in the experiments discussed. The application of these improved techniques by the small commercial growers who constitute the main producers of tomatoes in Trinidad is of special importance in that, as a result of their use, they should be able to produce a greater yield of fruit on the same area of land at a cheaper price with very little further outlay than at present, either in labour or actual cash.

Despite the great increases in early and total yield of pot-produced plants, the difficulties of obtaining and making up good composts, the costs involved in the production of the plants, the distances of travel from home to garden should the garden be far from the house as it often is, and the possibility of theft of plants if they were produced actually at the garden, all militate against application of the improved techniques. Their use at present is of more value to the home gardener.

Improved techniques in producing seedbed plants can, however, be applied with little extra cost but with a marked increase of yield. It has been

shown clearly that the amount of space allowed plants in seedbeds has a direct effect on their subsequent production in the field. Furthermore, growth from the sowing of seed to the production of the crop should be continuous and should have no setbacks. If setbacks occur, early and total production of fruit will be affected. The small amount of extra labour involved in the preparation of a larger area of seedbeds, the extra care in sowing, thinning and subsequent transplanting would be more than compensated by a much greater increase of value of the higher early and total yield produced.

Again, the application of a small amount of soluble fertilizer at planting out not only results in a marked increase of early yield but has a considerable effect on total yield. SAYRE (1939) states that the principal effect of a starter solution is to enable the plant to become established quickly, resulting in earlier maturity. It is said to be particularly effective with plants grown under crowded conditions and which are likely to be low in minerals at the time they are transplanted. Considering the fact that under local conditions plants are usually given a small amount of water at transplanting by hand, the cost of addition of a minute amount of fertilizer per plant is negligible in comparison with the value of the extra early and total yield obtained.

SUMMARY

Experiments on tomatoes over a period of four years have shown that care and attention given to the original environment of the seedling has a marked effect on the mature plant, not only on early and total yield but also on the number of necessary replacements.

Plants, grown in 3 in. clay pots, under open-sided greenhouse conditions and later transplanted to the field, have been markedly superior to plants produced on open seedbeds, when the seed has been originally broadcast thickly. If seedlings are spaced 3 in. × 3 in. on an open seedbed, results are intermediate between those of the pot method and the local broadcast seedbed method.

The application of a mixed soluble fertilizer or ' starter ' solution at the rate of $\frac{1}{4}$ pint per plant at transplanting has markedly increased early and total yields of fruit.

ACKNOWLEDGEMENTS

Acknowledgement is due to Messrs M. J. Smith, R. J. R. Barrett, R. E. Tremeer and J. S. Fenwick, formerly post-graduate students, for the use of data from their reports.

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The Role of 2, 4, 5-T Butyl Ester in the Control of Leaf Abscission in some Tropical Woody Species

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In an earlier paper experiments were described which demonstrated that senescent leaves of a number of British species produced a chemical substance which had the property of accelerating abscission (Osborne, 1955). This abscission factor, so far unidentified chemically (although it does not appear to be any of the more common sugars, amino-acids, purines or pyrimidines) has been shown to counteract the retardation in abscission which occurs when excised abscission zones from the primary leaves of bean plants (*Phaseolus vulgaris*) are treated at the distal end with indole-3-acetic acid (IAA). It was then proposed that leaf fall might be controlled not only by the gradient of endogenous auxins across the blade, petiole and stem, as has been suggested by Addicott *et al.* (1955), but also by the development of the abscission-accelerating factor which increases as the leaf matures and which appears to reach a maximum at senescence, just prior to leaf fall.

In recent years it has been considered advantageous to remove leaves from certain species without inflicting undue damage on the plant. The most important commercial application of this is the defoliation of cotton prior to the harvesting of the bolls. The removal of the leaves before mechanical picking ensures a relatively trash-free product, and also prevents the lint from becoming stained by sap from damaged leaf tissue. Considerable work has been done in the United States of America to find suitable and effective methods of defoliation and many investigations have been carried out in attempts to elucidate some of the physiological processes which occur during leaf fall. In general, the method of defoliation has been to apply chemicals which either dehydrate or damage the leaves to such an extent that much of the tissue is killed before abscission ensues. A true acceleration of abscission without apparent dehydration or necrosis has been demonstrated by van Overbeek *et al.* (1955) in cut twigs of peach following the spraying of the foliage with 2, 4-dichloromaleimide. In other species abscission has been accelerated by exposure to low concentrations of ethylene or hydrocarbon vapours. These methods have not found an application outside the laboratory.

As early as the 1930s it was suggested that defoliation of the trees in tsetse-infested areas of bush might offer a reasonable and economic means of altering the microclimate for a period sufficiently long to render the

* The work was carried out in the Botany Department, University College, Ibadan, Nigeria.

conditions unsuitable for the fly to breed, but it was not until the years after 1945 and the advent of new types of phytotoxic chemicals that this suggestion became a possibility. Holly (1952) carried out an extensive screening of many chemicals to determine those most satisfactory for inducing defoliation in tropical species in East Africa. The results of his work gave a clear indication that substances of the synthetic growth-regulator type, 2, 4-dichloro- and 2, 4, 5-trichloro-phenoxyacetic acids (2, 4-D or 2, 4, 5-T) were very effective as defoliants when applied to the leaves either as single drops or as a total cover spray from aircraft. In some cases, considerable damage was caused to the leaf prior to abscission, but certain species (e.g. *Combretum parvifolium*) shed their leaves while they were still green and visibly unharmed.

When 2, 4-D or 2, 4, 5-T are applied to the foliage of temperate species, a true acceleration of abscission is not normally observed. Where leaf fall does occur there is considerable injury to the tissues comparable with that obtained when phytotoxic substances, such as borates or chlorates, are used, and as far as the author is aware there have been no reports so far of the abscission of green or undamaged leaves following these treatments. The usual response to lower doses of these growth regulators is either a firmer adherence to the branch and a delay in abscission or no observable effect at all.

Chemicals of the synthetic growth-regulator type may well become important for defoliation in tropical agriculture. The apparent disparity in the responses of temperate and tropical species to this group of compounds has warranted a more critical investigation into some of the physiological changes which follow these treatments. The present paper describes that part of the general investigation on the physiology of abscission which was carried out with tropical species in Nigeria and includes, in particular, a study of the production of the natural abscission factor and its importance in the control of leaf fall in the tropics.

MATERIAL AND METHOD OF EXPERIMENTAL DEFOLIATION

Defoliation experiments using the *n*-butyl ester of 2, 4, 5-trichlorophenoxyacetic acid were carried out on a number of well established shrubs or trees of different woody species. Solutions of the compound were made up in 95 per cent alcohol, and were applied to mature leaves by means of an 'Agla' micrometer syringe. A measured drop (0·0025 ml) was placed on the upper surface of the lamina on either side of the main vein, the dose per leaf being determined by the concentration of the solution.

There were at least 20 leaves in each treatment, distributed either on replicate shoots on different trees or on widely spaced shoots on the same tree. Drops of 95 per cent alcohol only were applied to control leaves. Observations were made daily. *Table 1* lists the responses obtained on some of the species treated during December 1956 and January 1957.

The different species varied considerably in their sensitivity to 2, 4, 5-T, but in all except Ixora leaf fall was accelerated. Leaves of Vernonia became very necrotic and yellow and the premature leaf fall can probably be attributed to the large amount of injury to both the blade and the petiole and not to a true acceleration of abscission. The higher doses of 2, 4, 5-T caused a

Figure 1. Leaves of Chrysobalanus orbicularis *treated with 0·5 mg 2, 4, 5-T. Tissue beneath treated spots green, yellow and senescent areas surrounding*

Figure 2. Leaves of Anona muricata *treated with 0·5 mg 2, 4, 5-T. Tissue beneath treated spots green, yellowing and senescent tissues surrounding*

Figure 3. Leaves of Combretum platypterum. *Right: normal abscinded. Centre: normal green. Left: treated with 0·5 mg 2, 4, 5-T; tissue beneath treated spots green, yellow senescent tissue surrounding*

Figure 4. Lagerstroemia Flos-Reginae. *Right: normal leaves; green, yellowing and senescent. Left: leaves treated with 0·5 mg 2, 4, 5-T; contact necrosis, narrow green band surrounding spot, remainder of blade in different stages of senescence*

Table 1. Responses of some tropical species to foliar applications of the n-*butyl ester of 2, 4, 5-T*

*Species**	*Dose (mg 2, 4, 5-T/leaf)*	*Foliar responses*
Vernonia amygdalina	0·5 0·125	*Rapid necrosis of the treated parts; rest of leaf yellowed. Leaf fall occurred within 2 weeks when much of the blade and petiole was injured.*
Chrysobalanus orbicularis	0·5	*Yellowing followed by desiccation except at the point of application of 2, 4, 5-T. Treated area remained fresh and green but finally dried after the desiccation of the surrounding parts. Leaf fall occurred 3–4 weeks after treatment. (See Figure 1.)*
Anona muricata	0·5	*Do.* *(See Figure 2.)*
Nerium oleander	0·5	*Treated parts of the blade remained normal and green, untreated parts turned yellow. Leaves abscinded 4 weeks later, quite undamaged.*
Combretum platypterum	0·5	*Yellowing of blade. Treated spots remained deep green. Abscission of fresh undamaged leaves within 2 weeks.* *(See Figure 3.)*
Lagerstroemia Flos-Reginae	0·5 0·25 0·125 0·05	*Treated parts developed necrosis within 48 hours; a surrounding band of tissue remained deep green while the rest of the blade yellowed and dried out just before leaf fall.* *(See Figure 4.)*
	0·007	*No necrosis. Treated spots remained deep green, surrounding areas yellowed. Experiment unfinished.*
Ixora congesta	0·5	*No effects.*

* No abscission of control leaves from any of these species during this period.

contact necrosis in Lagerstroemia but a narrow zone immediately around the treated spots remained green and normal (*Figure 4*). The rest of the blade turned yellow and eventually became desiccated. The lowest dose (0·007 mg) caused no injury at all; the treated area remained normal and green while the rest of the blade became progressively yellow. Regrettably, in this case, the author returned to England before leaf fall had occurred. With Nerium and Combretum, also, the treated spots remained green and visibly normal, while the surrounding areas turned yellow, and abscission of these leaves occurred while they were still in an undamaged condition showing no sign of necrosis or desiccation. The responses of Chrysobalanus and Anona were similar but the untreated areas became desiccated before leaf fall finally took place.

The yellowing of the 2, 4, 5-T treated leaves followed a standard pattern. The tissue around the 2, 4, 5-T spots discoloured first, followed by the areas adjacent to the veins; the intervening mesophyll retained its green colour longest. In naturally senescent leaves, by contrast, the colour change occurred first in the mesophyll and the areas next to the veins were the last to turn yellow (see *Figure 4*). These effects are discussed in detail later in the paper.

Evidence for the presence of an abscission factor in senescent leaves of tropical species

A preliminary investigation was carried out to ascertain if an abscission-inducing factor was present in the petioles of young, mature and senescent

leaves of tropical shrubs and trees. The methods were similar to those previously used in experiments with British species (Osborne, 1955).

A section, approximately 3 mm long, was cut from the petiole of the leaf under test, and sealed with a 1 mm disc of 2 per cent agar to the freshly cut pulvinar end of a 1 cm long section, cut from the primary leaf of *Phaseolus vulgaris* var. Canadian Wonder. The bean sections, or 'explants', included the whole of the distal pulvinus, the abscission zone and a portion of the petiole below (*Figure 5*). They were aligned on grooved Perspex racks mounted over 3 per cent agar in Petri dishes and maintained at 25° C ± 2° C in a temperature-controlled dark room. The Petri dishes were enclosed in large desiccators containing a shallow layer of water to prevent drying out. At intervals of several hours the pulvinar end of the explant was lightly tapped and the number of explants in which separation had taken place at the abscission zone was recorded. Sections of petiole from senescent leaves of *Vernonia amygdalina*, *Nerium oleander*, and *Rospola*, *sp.* (Acanthaceae) were found to accelerate abscission of the bean explants.

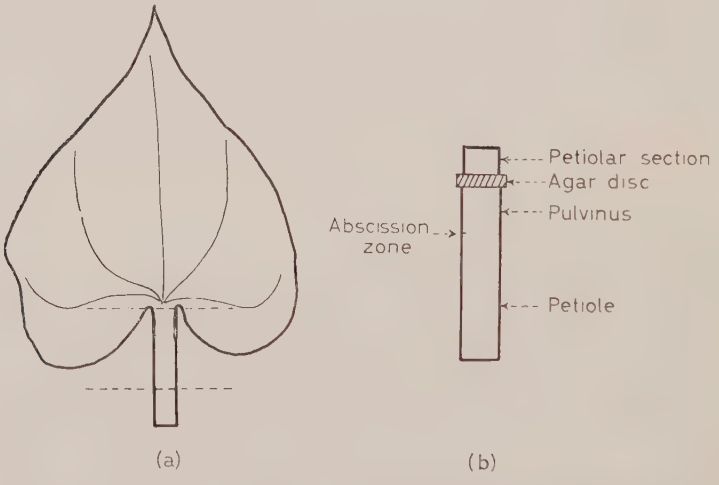

Figure 5. (a) Phaseolus vulgaris *leaf showing the portion which is excised for the 'explant'. (b) Explant with attached agar disc and petiolar section*

If sections of these petioles, as well as those of *Jatropha sp.* (Euphorbiaceae), were sealed at their proximal cut surface to 3mm³ blocks of 2 per cent agar for 24 hours, and the blocks then applied to the pulvinar end of a bean explant, abscission occurred more rapidly than in those explants supplied with plain agar blocks. However, with certain species, such as *Combretum platypterum* and *Chrysobalanus orbicularis*, abscission of bean explants was delayed or entirely prevented by the application of sections from green or senescent petioles or by agar blocks containing petiolar diffusates from these species. In these instances, there was frequently a premature rotting of the treated explants. This did not preclude the possibility of the abscission factor being produced in these species, since the failure of bean explants to respond to the diffusates from petioles of Combretum or Chrysobalanus could result

from the presence of other substances which are injurious to bean tissues. The diffusates might not be injurious if applied to their own species.

To check this point, experiments were carried out in which comparable sections of petiole from 2, 4, 5-T-treated and untreated Combretum leaves were sealed with agar on to bean explants and also on to explants cut from fresh young shoots of Combretum.

The leaves of this species are arranged in opposite pairs and explants were cut from shoots comprising only six pairs of leaves. The blades were removed at the junction with the petiole, leaving stumps some 0·5 to 0·7 cm long. The paired petiolar stumps were cut out from the shoots leaving approximately 0·5 cm of stem on either side of the abscission zones (*Figure 6*). 0·001 ml of an aqueous solution of the sodium salt of 2, 4-D at 10 p.p.m. was applied to the cut end of each petiolar stump on some of the explants to delay abscission. Other explants received 0·001 ml of water. A disc of 2 per cent agar 1 mm thick was then sealed to this cut surface followed by a section of petiole from an appropriate Combretum leaf. These explants were mounted on racks over 3 per cent agar and kept in desiccators as described for bean explants.

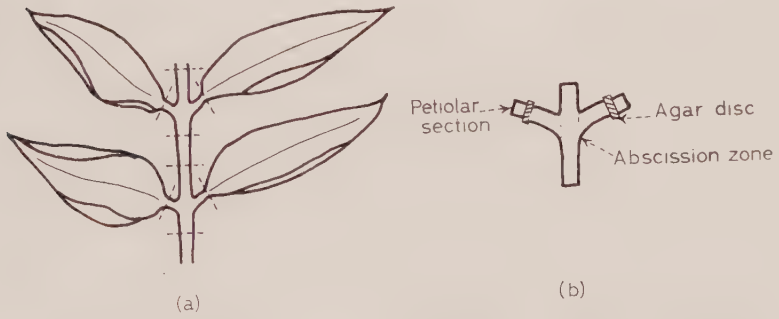

Figure 6. (a) *Part of shoot of* Combretum platypterum *showing portions which are excised for the 'explants'.* (b) *Explant with attached agar discs and petiolar sections*

The percentage abscission of bean and Combretum explants following the application of comparable petiolar segments of Combretum leaves from (*a*) young green, (*b*) mature green, (*c*) naturally abscinded yellow, and (*d*) 2, 4, 5-T-treated abscinded leaves is given in *Table 2*. The bioassay with Combretum explants demonstrates that untreated leaves of Combretum produce an increasing amount of the abscission factor as the leaf ages; as in British species, this appears to reach a maximum at senescence. It is also evident that leaves which have become prematurely senescent as the result of an application of 2, 4, 5-T produce effective quantities of an abscission-accelerating substance. It may be this compound, or other substances produced as the leaf ages, which are injurious to bean explants and mask the abscission-accelerating property of the petiolar diffusate. The application of the petiole of a yellow and senescent Combretum leaf to a Combretum explant treated with 0·001 ml 2, 4-D, 10 p.p.m., entirely counteracts the delay in abscission induced by the 2, 4-D and causes separation to

occur more rapidly than that in explants treated with water. Similar results have been obtained with temperate species. Diffusates from all the British species investigated to date have been found to negate the abscission-delaying action of both IAA and 2, 4-D in bean explants.

Table 2

Percentage abscission of explants of bean (Phaseolus vulgaris) *and* Combretum platypterum *to which have been sealed sections of petiole from 2, 4, 5-T-treated (0·5 mg/leaf) and untreated leaves of Combretum. (0·001 ml 2, 4-D, 10 p.p.m. or 0·001 ml water was applied distally to each debladed petiole of the Combretum explants before addition of agar discs and petiolar sections.)*

	Percentage abscission					
		Agar disc + petiolar section from:				
BEAN EXPLANTS	*Control agar disc only*	*Untreated young green leaves*	*Untreated mature green leaves*	*Untreated yellow leaves abscinding naturally*	*Leaves treated with 2, 4, 5,T. yellow and abscinding*	
Abscission at 100 h	90	90*	50	67* *Some toxicity*	37* *Toxicity*	
COMBRETUM EXPLANTS	*Water added*	*2,4-D added*	*2, 4-D added*			
Abscission at 71 h	58‡	0†	0	8†	83	92†

* Significantly different from other treatments at 5 per cent level.
† Significantly different from other treatments at 5 per cent level.
‡ Significantly different from data for abscinding leaves at 10 per cent level and from other data at 5 per cent level.

When growth substances are applied to leaves in the light there is abundant evidence that the compound is absorbed by the leaf and passes down the petiole and may become distributed to many parts of the plant (Leonard and Crafts, 1956). It might be expected, therefore, that 2, 4, 5-T applied to the leaves of tropical species would also be translocated in this way. It is well known that IAA or many of the synthetic growth substances will retard the abscission of the petiolar stumps of leaves from which the lamina has been removed (Gardner and Cooper, 1943). It was pertinent therefore to determine whether this also occurred in tropical species.

The blades of attached leaves of *Combretum platypterum* and *Lagerstroemia Flos-Reginae* were severed at their junction with the petiole and either a drop of the 2, 4, 5-T ester in 95 per cent alcohol or an equal-sized drop of 95 per cent alcohol alone was applied to the cut end of alternate petioles along the shoot. The experimental results, listed in *Table 3*, show that when 2, 4, 5-T is applied directly to a petiole in this way abscission is considerably delayed. Thus, it may be concluded that at these doses the normal action of 2, 4, 5-T when applied distally to the abscission zone is to retard abscission in both temperate and tropical species, and that the abscission-accelerating effect of a foliar application of 2, 4, 5-T is likely, therefore, to be the result of secondary reactions.

Table 3. Average time from treatment until abscission of control and 2, 4, 5-T-treated debladed petioles on trees of Combretum platypterum *and* Lagerstroemia Flos-Reginae

Species	*mg 2, 4, 5-T/ petiole (0·0005 ml drop)*	*Mean time between treatment and abscission (h)*	
		Control petiole	*2, 4, 5-T-treated petiole*
Lagerstroemia Flos-Reginae	0·005	49	>432
Combretum platypterum			
Tree 1	0·005	35	68*
Tree 2	0·005	69	89*
Tree 3	0·005	40	96*

* Difference in abscission time between 2, 4, 5-T-treated and control petioles significant at 5 per cent level.

The abscission-controlling effect was then studied of petiolar diffusates from leaves of both species treated with 2, 4, 5-T starting from the time of application of the ester until the senescence and fall of the leaf.

Time study on diffusates

(1) *Combretum platypterum*—The 2, 4, 5-T ester was applied to one leaf of each pair along one side of a number of shoots. The opposite leaves of each pair were left untreated and acted as controls.

Petiolar sections were excised from these treated and control pairs of leaves at intervals from the time of application of the 2, 4, 5-T until a partial yellowing and senescence of the treated leaves had occurred. Each section was sealed by an agar disc to the petiolar stump of an explant freshly cut from untreated Combretum shoots. The results from a number of these experiments are shown in *Table 4*: they demonstrate that six hours after the application of 2, 4, 5-T to the leaf the diffusate from the petiole contains substances that retard abscission. This property decreases with time and after 30 hours the action of the diffusate from the treated leaf is reversed and an increasing abscission-accelerating property is developed.

In other experiments, Combretum shoots were sectioned up into explants after varying intervals of time from the application of 2, 4, 5-T and without further treatment they were mounted on racks over agar in the usual way. The average time for abscission of the petiolar stumps from these explants is shown in *Table 5*. In both experiments, the abscission of the petiolar stump of the 2, 4, 5-T-treated leaf is initially delayed compared with that of its opposite control. Subsequently the effect is reversed, and the stumps from the treated leaves abscind more rapidly.

A similar sequence of results to those shown in *Tables 4* and *5* was obtained if the 2, 4, 5-T-treated and untreated leaves were separated on to different, but comparable, shoots of the trees. There would therefore seem to be no marked influence of a 2, 4, 5-T-treated leaf upon its untreated neighbour, and there was no visible evidence of translocation of 2, 4, 5-T to other parts of the tree.

Table 4. Average time for abscission of Combretum platypterum *explants to which have been sealed by agar discs sections of petiole from 2, 4, 5-T-treated (0·5 mg/leaf) and untreated leaves of* Combretum. *Sections excised at intervals from the application of 2, 4, 5-T until the senescence of the treated leaves. (0·001 ml water was applied to the petiolar stumps of each explant before application of the agar disc.)*

Duration of treatment before excision of petiolar sections (h)	*Average time for explants to abscind (h)*			*Difference in abscission time between explants sealed with a section from a 2, 4, 5-T-treated leaf and those sealed with a section from an untreated leaf*
	Agar disc control	*Agar disc + section of petiole from:*		
		Untreated leaf	*2, 4, 5-T-treated leaf*	
6	—	55	70	15 *h retardation**
24	55·0	56	64	8 *h retardation**
30	—	59	41	18 *h acceleration**
48	88	78	54	24 *h acceleration**
96	84	77	51	26 *h acceleration**
(Abscission of all 2, 4, 5-T-treated leaves within 7 days				

* Values significant at 5 per cent level.

Table 5. Average times for abscission of explants excised from Combretum platypterum *at varying times from the application of 2, 4, 5-T (0·5 mg) to the leaves on one side of the shoots. 0·001 ml water was applied to the petiolar stumps on each explant*

Duration of treatment before excision of explant (h)	*Average time for petiolar stumps to abscind (h)*		*Difference in abscission time between stump of 2, 4, 5-T-treated and untreated leaf*
	Untreated leaf	*2, 4, 5-T-treated leaf*	
Expt 1 6	54	67	13 *h retardation**
Expt 1 30	56	50	6 *h acceleration*
Expt 1 93	35†	21†	14 *h acceleration**
Abscission of 2, 4, 5-T-treated leaves within 7 days			
Expt 2 48	45	63	18 *h retardation**
Expt 2 97	52	45	7 *h acceleration**
Abscission of 2, 4, 5-T-treated leaves within 10 days			

* Values significant at 5 per cent level. † Bioassay at 30° ± 2° C.

(2) *Lagerstroemia Flos-Reginae*—Shoots of Lagerstroemia were too large to make convenient explants and a different type of bioassay was therefore used. Green shoots up to 12 in. long were cut from the trees. The leaf blades were removed at the junction of blade and petiole and a disc of agar was sealed to the cut surface of each petiolar stump. A section of petiole from a 2, 4, 5-T-treated or untreated Lagerstroemia leaf was sealed to some of these stumps, while other stumps served as controls (*Figure 7*). The basal end of each shoot was placed in a flask of water and the whole system was enclosed in a saturated atmosphere at 25° C ± 2° C. The petiolar stumps were lightly tapped at intervals to determine when abscission had occurred.

Petiolar sections from naturally senescent leaves were found to accelerate abscission of the stumps, *Table 6* (Expt 1), while sections from leaves treated with 2, 4, 5-T delayed abscission even though they had become senescent (Expt 1). These treated leaves did not, however, undergo normal abscission at senescence, but frequently remained ' frozen ' to the tree until all but the

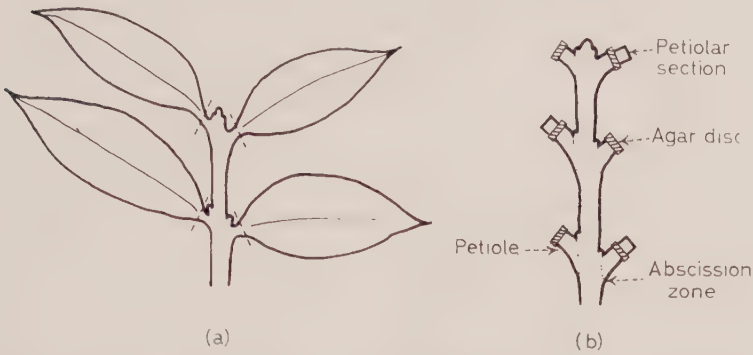

Figure 7. (a) *Shoot of* Lagerstroemia Flos-Reginae *showing point of severance of leaf blade and petiole.* (b) *Experimental shoot with attached agar discs and petiolar sections*

Table 6. Average time for abscission of petiolar stumps on excised shoots of Lagerstroemia Flos-Reginae *to which have been sealed an agar disc followed by a petiolar section from a 2, 4, 5-T-treated or an untreated leaf of the same species*

Dose of 2, 4, 5-T/leaf (mg)	*Duration of treatment*	*Time taken (h) for abscission of petiolar stumps sealed with:*				
		Agar disc only	*Agar disc + segment of petiole from:*			
			Untreated leaf (green)	*Untreated senescent leaf (yellow)*	*2, 4, 5-T-treated leaf (green)*	*2, 4, 5-T-treated leaf (senescent and yellow)*
Expt 1 0·25	10 *days*	>123	137	70*	—	>168
0·125	3 *days*				>168	
	10 *days*				—	>168
(*Treated leaves became senescent and desiccated before leaf fall.*)						
Expt 2 0·05	30 *h*	128	130		>192	
(*Treated leaves became senescent, a few abscinded turgid, rest became desiccated before leaf fall.*)						

* Significantly different from other treatments at 5 per cent level.

base of the petiole was dead and dry before leaf fall occurred. Doses of 0·05 mg caused some leaves to yellow and abscind without injury, but the majority of leaves, even at this low dose, remained 'frozen' until the blade tissue became quite desiccated. Petiolar sections from such leaves, taken 30 hours after the application of 2, 4, 5-T, delayed abscission of petiolar stumps (Expt 2). Sections from untreated green control leaves had little or no effect upon the abscission of the stumps to which they were sealed. Doses as low as 0·007 mg 2, 4, 5-T per leaf caused no necrosis and by 13 days the treated area of blade was deep green and the surrounding regions had started to yellow (*Table 1*). A number of these shoots were cut from the tree at varying intervals after the application of 2, 4, 5-T, and the blades severed from the treated and untreated leaves at the junction with the petiole. The shoots were kept in a saturated atmosphere with their

basal ends in water and the average time for the abscission of the petiolar stumps is shown in *Table 7*. For 7 days after treatment with 2, 4, 5-T, abscission is delayed, but by 13 days, the petiolar stumps from the treated leaves (which then show the first signs of senescence with the treated areas remaining green), abscind as readily as the controls.

Table 7. Average time for abscission of petiolar stumps of 2, 4, 5-T-treated (0·007 mg/leaf) and untreated leaves of Lagerstroemia Flos-Reginae. *Shoots cut from the tree at varying times after application of 2, 4, 5-T until first signs of senescence of treated leaves 13 days later*

Duration of treatment before testing	*Average time for petiolar stumps to abscind (h)*		*Difference in abscission time between stump of 2, 4, 5-T-treated and untreated leaf*
	Untreated leaf	*2, 4, 5-T-treated leaf*	
24 *h*	136	184	48 *h retardation**
72 *h*	132	156	24 *h retardation*
7 *days*	124	136	12 *h retardation**
13 *days*	77†	77†	0 *h retardation*

* Values significant at 5 per cent level. † Bioassay carried out at 30° ± 2° C.

DISCUSSION

The present experiments have shown that the application of 2, 4, 5-T at suitable concentrations to the leaves of tropical species results in the treated spots retaining their normal green appearance, while the surrounding areas undergo a premature yellowing and senescence. Naturally senescent leaves produce an abscission-accelerating factor which can be demonstrated in the diffusate from the cut end of the petiole, while the diffusate from the petioles of wholly green leaves either does not contain the factor, or contains it together with other substances which cause it to be comparatively ineffective. When 2, 4, 5-T is applied to a leaf, the diffusate from the petiole initially possesses an abscission-retarding activity, which could be accounted for by the translocation of 2, 4, 5-T down the petiole from the blade. It was shown that when 2, 4, 5-T was applied to the cut end of debladed petioles separation was retarded in the abscission zone below (*Table 3*). The abscission-retarding activity of the petiolar diffusate decreases with time (*Tables 4, 5* and *7*) and is replaced by an abscission-accelerating activity in those leaves in which senescence is accompanied by little or no visible desiccation or necrosis. This result suggests that an abscission-accelerating factor is produced in these leaves as a consequence of treatment with 2, 4, 5-T, and that either 2, 4, 5-T eventually ceases to be translocated down the petiole or that if it is continuously transported, its retarding effects on abscission are counteracted by the abscission factor. The abscission-delaying effect of 2, 4-D, for instance, is negated by diffusates from segments of naturally senescent Combretum petioles (*Table 2*).

The retention of the green colour in the treated areas of the blade may give the clue to the defoliating action of compounds such as 2, 4, 5-T. The ester, after evaporation of the alcohol solvent, remains as a slight oily layer over the treated surface. This residue probably acts as a source of the compound for a long period. Synthetic growth substances (2, 4-D, 2, 4, 5-T) have been shown to increase the respiration in treated tissues (French and Beevers, 1953). If the 2, 4, 5-T applied to the leaves of these

tropical species were to remain in a considerably higher concentration in the areas directly treated than in the surrounding parts, the treated areas might have a relatively higher metabolic activity. This could cause a drain of metabolites from the areas of low 2, 4, 5-T concentration to those of high concentration. If this process continued for many hours, the treated areas might be considered to be partly parasitic upon the areas of lower metabolic activity, and the continual drain on the reserves of metabolites in the untreated areas of blade should induce in them a premature ageing and senescence of the tissues. This suggestion is supported by the fact that the areas immediately adjacent to the treated parts turn yellow first (*Figure 4*), discoloration spreading along the veins and finally extending to the whole of the untreated areas. It is proposed that as these areas become progressively senescent they produce increasing amounts of the abscission factor which passes down the petiole and eventually counteracts the abscission-retarding effect of the 2, 4, 5-T translocated from the blade, ultimately causing the diffusate from the petiole to possess an abscission-accelerating activity (*Tables 4*, *5* and *7*).

Provided the amount of 2, 4, 5-T applied to the leaf is small enough for its effect to be eventually more than offset by the subsequent production of the abscission factor, a premature leaf fall should occur and 2, 4, 5-T may be considered to have a defoliant action. If the dose of 2, 4, 5-T is too high, senescence will still take place, but the abscission factor produced may never reach a sufficiently high level to counteract the 2, 4, 5-T that passes down the petiole, and the eventually desiccated leaf may remain 'frozen' to the tree for some while before leaf fall finally occurs (Lagerstroemia. *Tables 1* and *6*).

The present investigation has provided additional evidence to show that synthetic growth regulators such as 2, 4, 5-T have little promise of becoming effective defoliants in mixed stands of tropical woody vegetation because of the wide difference in sensitivity of the different species. Where one species only occurs, the optimum dose for inducing senescence with minimal injury can readily be determined experimentally. Under these conditions growth regulators may eventually become useful as defoliants.

The difference between the responses of temperate and tropical species to foliar applications of growth regulators may be due in part to the way in which the applied growth substance becomes distributed within the leaf tissue. If it becomes fairly evenly dispersed then the whole leaf should have a similar metabolism and no one part of the leaf should become senescent before another. So far, no record has been found in the literature of a differential senescence in temperate species, of a type which is described in this paper. The usual response is either necrosis and death of the tissue, which results in the leaves freezing on for a considerable period, or no visible response at all. It may be, therefore, that the dose required to cause senescence and the production of the abscission factor is very close to that which causes rapid necrosis, so that the level of the abscission factor produced may never rise high enough to counteract the applied growth regulator. The petiolar diffusate would then always retain an abscission-retarding property. Further investigations on temperate species are in progress, and will be published elsewhere.

SUMMARY

N-butyl, 2, 4, 5-trichlorophenoxyacetate (and allied plant growth reguators) are effective defoliants of many tropical woody species when they are applied as droplets to the leaf lamina. Experiments designed to investigate the nature of the defoliating action of this type of compound are described.

All naturally yellow and senescent leaves of the species tested were found to produce a substance which accelerated abscission in abscission zones of their own species. Little or none of this substance could be demonstrated in green leaves.

After an application of 2, 4, 5-T to green leaves an abscission-retarding activity could be demonstrated in diffusates from the petiole. This activity decreased with time and was replaced by an increasing abscission-accelerating activity prior to leaf fall. The areas around the treated spots were by then visibly yellow and senescent, while the treated areas retained their green colour.

It is proposed that compounds such as 2, 4, 5-T exert their defoliating action in tropical species by causing local increases in metabolic activity below the droplets. This results in a drain of the metabolic substrates from the surrounding areas to the treated areas and causes a premature senescence in the untreated parts of the blade. As these areas become progressively senescent, increasing amounts of the abscission-accelerating substance are produced and a premature leaf fall ensues.

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Book Reviews

INSECT LIFE IN THE TROPICS

T. W. Kirkpatrick. Longmans Green: London, 1957. xiv+311 *pp.* (illus.) 35*s*

Much that might have been written in a review of Professor T. W. Kirkpatrick's book *Insect Life in the Tropics* is said by the author himself in his preface. His aim, he says, is ' to give some idea of the life histories and habits of tropical insects so that anyone living permanently or temporarily in a tropical country may gain a little knowledge of what is going around him in the insect world; it is not addressed primarily to trained entomologists '.

It is without question a most interesting book, and not least for the trained entomologist. It is written clearly and the author wears his erudition well. His quotations from Genesis to Ogden Nash are apt. The illustrations are refreshingly new, and are generally well situated to support the text. Many years spent in Egypt, the Sudan, East Africa and Trinidad have provided the author with personal experience of tropical insects in a wide variety of habitats, and reduced to a minimum his need to refer to other writers. The fact that so many examples have, of necessity, to be drawn from insects of economic importance serves to emphasize the scope that there is for work on tropical insects that do not appear to interfere with man.

After dealing briefly with the general structure of insects and with their classification, the book proceeds in seven chapters to consider their development, reproduction, feeding, locomotion, defence, architectural abilities and their social life. Some aspects are touched on in greater detail than others, a reflection no doubt of Professor Kirkpatrick's personal interests, and we find short essays on such topics as protective resemblance in Lepidoptera, protective secretions in Homoptera, nest construction in bees and wasps, the behaviour of a parasitic Chalcid *Kapala furcata*, and the biological control of black sage in Mauritius.

The naturalist transplanted to the tropics all too often becomes bewildered by the infinite variety of animal life there, and the presence of so many more conspicuous species to attract the attention than are usually met with in temperate climates. In so far as insects are concerned, this book will help the beginner to focus his interests on some particular facet of their natural history, by providing a choice of backgrounds, with interesting examples of the kind of thing other people have already worked out.—W.V.H.

THE NIGER AGRICULTURAL PROJECT

K. D. S. Baldwin. Blackwell: Oxford, 1957. xvi+221 *pp.* (illus.) 27*s* 6*d*

The Niger Agricultural Project at Mokwa in Northern Nigeria began operations in 1949; the company was liquidated as a failure in 1954, with a net loss to the Colonial Development Corporation of £123 000. As the

only part of the ' West African Groundnuts Scheme ' ever to be put into practice, and as one of the earliest examples of partnership between the Corporation and a colonial government in agriculture and of large-scale mechanization in West Africa, the scheme attracted particular interest at the time.

To rake over the embers of past failures may be felt as unsavoury. But in this case the author is to be congratulated on his extremely lucid analysis of the reasons for failure, and the Colonial Development Corporation on their suggestion that he should undertake the study on this scale. Mr BALDWIN has with great skill carried out his task without any personal denigrations; such were in fact uncalled-for, since the persons involved were at almost all levels given impossible objectives by their superiors, and there is no evidence that they did anything but their best.

The reasons for lack of success were both basic and incidental; there is no need to recapitulate them here, since Mr BALDWIN has analysed them with the acuity of a trained and experienced observer. His book is itself the best thing to come out of the Mokwa scheme, and should be required reading for all who are concerned with future schemes of agricultural development in the African tropics.—G.B.M.

THE ECONOMICS OF UNDERDEVELOPED COUNTRIES

P. T. BAUER and B. S. YAMEY. Cambridge University Press: London, 1957. 271 *pp.* 10*s* 6*d*

This small handbook should be compulsory reading for all politicians, planners and advisers to underdeveloped countries. Neither should agricultural officers ignore it; they have as much to learn as those concerned with the overall development of a country.

It is unfortunately becoming only too common these days for public opinion in underdeveloped countries, which are trying to better their standards of living, to assume that no conscious efforts at development have been made in the past; that what is required in place of the ordinary commercial enterprise of past decades is a plan of development drawn up by an impartial and paternal government. It is assumed further that such a plan, whatever its exact constitution, will almost automatically increase total production when put into effect. Indeed, in many of these countries the hose of economic common sense needs training on development plans, not so much to dampen the ardour of the planners as to ensure that the fertilizing scraps of public money are washed into channels that will benefit most acres and not into stagnant pools.

The authors have laid out their work in two parts: first, the groundwork study of the economic characteristics of underdeveloped countries; secondly, an examination of the likely benefits of various government actions upon them. Both parts maintain a high standard of economic analysis without being over-technical or abstruse. The layman need have no fear of economic jargon in this book.

In the first part the recurrent theme is that poor utilization of resources is due to lack of opportunity (or lack of choice) to use them. Not only is labour wasted when it can be applied only to seasonal farming, but

enterprise does not develop when there is little or no opportunity for being enterprising; capital is not accumulated when the only recognized avenue for investment is in decorative but unproductive cattle. The authors are optimistic and at the same time convincing about these unused, latent resources. They point out that even the poorest countries and individuals have in the past somehow succeeded in creating capital from their own savings when the inducement has been strong enough; that entrepreneurship has developed at a surprising rate wherever scope for its application has occurred. In this section considerable attention is given to leisure (satisfaction consumption) versus production. The agriculturist should also take another theme to heart: that the subsistence economy, by severely restricting choice, precludes economic development.

In the second part the authors use their previous analysis as a basis on which to judge the wisdom and possible effects of various government actions. The important theme of this part is that government does not create economic resources, it can only re-allocate them. This is an obvious truism but one which is for convenience only too often ignored today. The greatest assistance a government can give to the development of a country is to advertise both at home and abroad as many economic possibilities as can be discovered; it should avoid restrictionism and favouritism of every kind whether to particular classes of people or industry or types of organization. It should strive to promote honest, unhampered competition on every hand. The writers point out that the welter of restrictions (or assistance) found in most developed countries does not in any way contribute to their wealth; they are tolerated because the country can afford them; but the poor one, if it is to progress, cannot.—A.L.J.

TYPES OF RURAL ECONOMY

René Dumont. Methuen: London, 1957. xii+556 *pp.* (illus.) 45*s*

There does not appear to be much of great value, though there may be something of interest, to the tropical agriculturist in this apparently quite imposing book. The bulk of it consists of rather sketchy case histories of villages and small groups of farmers in underdeveloped countries ranging from North and West Africa to the Far East and back to Europe. The author has also included odd chapters on more advanced countries such as Holland and the United Kingdom.

The author has obviously travelled far and seen much but it is a pity that he has not succeeded in winnowing and organizing his impressions into a more purposeful book. Most of his case histories read rather like a transcription of field notes; they do not appear to have been arranged or selected with any overall purpose in mind. He confuses the reader by failing to provide adequate maps and his diagrams of cropping patterns and farm layouts do not add much to the text.

In his preface the author states that ' this book is the work of an agronomist who has indulged his interest in economic problems . . . but too late in life . . . ' Some statements that appear in his introductory and summary chapters confirm this statement only too well. He appears to be completely and uncritically convinced by Malthusian thinking of a most desperate

kind. He advocates ' organized ' and large scale agriculture as a method of increasing output without discussing or evidently being aware of the possible difficulties and disadvantages. Some statements can be classed as little less than wild; for instance: ' The centuries-old tradition of depriving the tropics of their necessities of life in order to improve its own [Europe's] standards '; ' The tractor is for agriculture what the steam engine was for the Industrial Revolution '; ' Every animal calorie consumed by a North American reduces the pitiable ration of the Mexican peasant [or Brazilian] by eight calories '.

It is a pity that so much observation and so much work in translation and production have gone into a book that makes such a poor impression in review.—A.L.J.

FARM MECHANIZATION HANDBOOK

T. Hammond Cradock. 3rd edn. Temple Press: London, 1957. ix+470 *pp.* (illus.) 25*s*

In its previous form *Farm Mechanization Handbook* was a valuable reference text for those concerned with maintaining British-made agricultural tractors at a high level of efficiency, particularly in locations without highly organized workshops and repair services. Although the new third edition is fundamentally the same as the second edition, its value has been increased by the inclusion of a number of new chapters, among which are: Decarbonizing the David Brown Diesel; Decarbonizing the Fordson Major Diesel; Decarbonizing the Field Marshall; and Decarbonizing the Nuffield Vaporizing Oil Engine, which are all well illustrated by means of photographs. The number of tractors for which service data are provided has been increased from 17 to 55, and since there are also four new chapters on tractor hydraulic systems, this handbook is now of even greater value for reference purposes.

Other new sections on: Buying a Used Tractor, and Electricity and the Tractor, are both welcome additions but the latter would have been better placed before the descriptions of magneto and coil ignition, and could be improved by including more information on electromagnetic induction and the elementary theory of transformers, a knowledge of which permits a fuller understanding of spark ignition systems.

Mr Cradock, very correctly, says that ' . . . . no matter what is written on engine maintenance, it cannot provide a complete substitute for skilled experience '—but in this new edition he has made an attempt to prove himself wrong on this point and the value of his book is such that he has almost succeeded.—P.H.R.

COLONIAL AGRICULTURE STATISTICS: THE ORGANIZATION OF FIELD WORK

K. E. Hunt. *Colonial Research Publication No. 22.* Her Majesty's Stationery Office: London, 1957. 123 *pp.* 14*s*

This publication is a substantially revised version of *Statistics for Colonial Agriculture* (*Colonial Research Publication No. 11*) which was published in 1952, and reviewed in this Journal **29,** 89.

The aim of this book, which is of an essentially practical nature, is ' to provide a guide to the agriculturist in organizing fieldwork, a background for the statistician who is planning surveys and a link between the two'. It is thus complementary to the standard texts on sampling methods and general economic statistics. The stimulating style and penetrating discussion make this a valuable handbook for all those who are concerned with agricultural statistics.

Although the scope of the work remains substantially the same, the considerable experience in the collection of agricultural statistics which has been gained within recent years has been freely drawn on and much new material has been included—with a corresponding increase in the number of references. The text has been thoroughly revised throughout. There has also been some rearrangement. The administrative and preparatory work involved in particular inquiries and in building up a statistical organization is now treated separately (Part II). This section has been further expanded by including a chapter on the selection and training of staff. The relevant field and office techniques are collected together in appendices in Part III. An index has also been added.—G.E.H.

ATOMIC ENERGY AND AGRICULTURE

Edited by C. L. Comar. American Association for the Advancement of Science, New York, 1957. 450 *pp.* 86*s*

ATOMIC ENERGY IN AGRICULTURE

W. E. Dick. Butterworths Scientific Publications, London, 1957. 150 *pp.* 15*s*

The two books* cover the same ground but from very contrasting viewpoints. Dr Comar has edited a series of 22 authoritative reviews presented at a symposium at Atlanta in 1955. Mr Dick's book is largely based on impressions he gained at the Geneva Conference on the Peaceful Uses of Atomic Energy held a few months previously. Unlike Dr Comar he has a popular audience in mind.

It is inevitable at any symposium that some contributions are more outstanding than others. The reviewer must, however, be cautious because of the danger of being biased by his own personal interests. There can be little disagreement with the opinion that in the Atlanta volume Dr Tolbert's review of photosynthesis, Dr Singleton's on the use of radiation in plant breeding, and that of Dr Comar himself and Mr Wasserman on macronutrient metabolism will compare favourably with any reviews of comparable length. Nearly one fifth of the book is devoted to an important series of papers on the sterilization of food by irradiation. The volume also includes a number of articles on plant nutrition and soil studies. To sum up: no review equally authoritative and comprehensive has hitherto appeared on the application of the by-products of atomic energy to agricultural problems.

Since Mr Dick is writing for a popular audience his book cannot be judged by similar standards. It is reasonable, however, to consider the extent to which he conveys, in popular language, the same impression as that given

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by Dr COMAR and his experts. In his last chapter devoted to food preservation Mr DICK has achieved an admirably readable and balanced review. The same cannot be said of his first chapter entitled ' Remaking crop plants with radiation '. The general tone of the chapter is indicated by the title and the following quotation: ' The practical possibilities [of radiation procedures] in plant breeding stir the imagination '. This approach can scarcely be expected to lead to unbiased judgement and though the article contains much interesting information the reader may gain the impression that the future of plant breeding lies largely at any rate in the hands of the operators of radiation sources. Dr SINGLETON's paper at Atlanta suggests no such sweeping conclusion. Mr DICK devotes other chapters to plant nutrition, photosynthesis, the control of pests and diseases and the study of forestry problems. The criticism already made regarding his discussion of genetics is sometimes applicable and a surprising omission is that nowhere is a clear statement made of precisely why tracer procedures have already led to such outstanding advances.

The dramatic nature of the hazards to which radiation could give rise and the outstanding opportunities it provides for research workers are a temptation to overstatement. Now that the second decade of serious work in these fields is beginning it is to be hoped that a greater sense of proportion will be achieved in popular exposition. Above all it must be realized that the greatest benefit of radiation procedures in agricultural research will emerge only slowly as a result of continuous research. No service is done by leading the general reader to expect too much too soon.—R.S.R.

FLOWERING TREES IN INDIA

M. S. RANDHAWA. Indian Council of Agricultural Research, New Delhi, 1957. 210 *pp.* (illus.) *Rs*15/-

Dr RANDHAWA, Vice President of the Indian Council of Agricultural Research, in the preface to this book states that it ' is a saga of the Tree Beautiful . . . the result of a decade of observation and worship of the beautiful trees in India ' and hopes that it ' will be useful to all those who are interested in trees and tree-lore, garden aesthetics as well as town and country planning '.

The book is an odd mixture of the fanciful and the practical. There are 32 chapters, which cover such subjects as trees in modern Indian art and folk-songs, ' a bioaesthetic plan ' and ' places susceptible of bioaesthetic planning ', which is defined ' as conscious planning of the flora and fauna with the object of beautifying the country '. Apparently we are indebted to Professor LANCELOT HOGBEN for this new word. Several chapters are devoted to the description of the trees and their horticultural uses. The chapter on ' Wanderings of Plants ' contains information on the centres of origin and the dispersal of herbaceous crops.

A liberal smattering of common Indian and English names of trees makes it difficult to follow for those of us who are unacquainted with India. As these names are not cross-indexed, it is impossible to know which plant is being referred to without going through all the tabulated information provided under families. Even the English names of trees can be very confusing,

e.g. the Flame of the Forest in India is *Butea frondosa*; in Malaya it is *Delonix regia* (known in India as *Gul mohur* and elsewhere in the tropics as Flamboyante), while in Uganda the Flame of the Forest is *Spathodea campanulata*, for which Dr RANDHAWA gives a choice of three English names—the Fountain tree, Scarlet Bell tree, both of which are new to me, and Tulip tree.

Dr RANDHAWA considers that ' The flowering of the forest trees is the spontaneous expression of the mystery of life. Contemplating the beauty of the trees, one experiences the joy of the Impersonal, when the inner self of man and the outer self of nature unite. In the union of the soul and nature one experiences ecstatic joy and forgets one's little self. Thrilled by the beauty of the blossoms of the forest trees, the sailing clouds, the golden sunsets and the splendour of the snow peaks, one feels elevated, and a rain of beauty seems to drizzle.' Those who enjoy this type of writing will find much to interest them in the book under review.

The pictures are also an odd mixture of styles and subjects. There are 38 full-page coloured plates. Those of scenes and trees in full bloom are not as successful as the individual sprays. Some owe much to the ' art calendar '. Others show the influence of the Impressionists; Plates 15 and 16 are very Chinese in character, while others, such as Plate 14, are very typically Indian. The painting of individual sprays also varies in delicacy of touch, style and quality. Some of them are rather ' heavy ', such as Plate 29, entitled ' The *Semal* tree meditates: Why are my flowers red? '.

I do not understand what the Minister of Community Development means in his Foreword when he says ' beauty is the birthright of man living in nature, and this can be provided in the countryside by nature's pheasantry and vegetation alone '.

The book is most reasonably priced and it is difficult to understand how this lavish production can be sold at 15 rupees, unless it is heavily subsidized. —J.W.P.

PLANT DISEASES DUE TO BACTERIA

W. J. DOWSON. 2nd edn. Cambridge University Press, London, 1957. 232 *pp.* (45 illus., 21 maps) 32*s* 6*d*

The first edition of this useful book was published in 1949. Since that date increasing knowledge of bacterial diseases and the development of new techniques of identification and control have rendered a second edition desirable, if not imperative.

In its expanded form, including a new chapter on the preservation of bacterial cultures, the book will find a welcome place on the bookshelves of all those concerned with the teaching of plant pathology or advising on bacterial problems in agriculture. It will also be of considerable value to students, and of interest to all microbiologists.—R.F.B.

COMMON DISEASES OF VEGETABLES IN SOUTH AFRICA

V. A. WAGER. Department of Agriculture, Pretoria, 1956. 176 *pp.* (illus.) 12*s*

' . . . In design the book is simple. Photography and illustrations are used extensively. Lengthy discussions and detailed descriptions have been

excluded, and the book has been planned for quick and easy reference. It will, I believe, be most useful for all growers of vegetables, and will be welcomed alike by home gardeners with a few vegetables in the garden and by farmers growing vegetables for their livelihood.'

The above is an extract from the foreword by Dr J. Van der Plank, Chief of the Division of Plant Pathology, Department of Agriculture of the Union of South Africa.

It is true that the book is helpful in the identification of vegetable pathogens, and that it is easy to use, but it does not appear to be directed to the gardener or farmer. If it is, several valid criticisms can be levied against it. Although the plants are arranged alphabetically the index gives only the Latin names of the pathogens, and not the common names of the diseases. Also many of the diseases are accompanied by somewhat diagrammatic drawings of fungal spores and fruiting bodies which would only be visible under the microscope or with a good hand-lens. Similarly dimensions of such things as spores, conidiophores, and perithecia are given wherever possible. This may be interesting but is hardly something the farmer would be expected to need.

Many of the photographs are extremely poor and in some cases three are given of the same leaf at different magnifications where one of the diseased plant and one of the leaf under reasonable magnification would have been of more use. It is a pity the number of photographs was not halved and the remainder reproduced in colour. If this had been done the book would have been excellent.—R.F.B.

SOUTH PACIFIC ENTERPRISE

The Colonial Sugar Refining Company Limited

Edited by A. G. Lowndes. Angus and Robertson: London and Sydney, 1956. xvii+500 *pp.* (illus.) 42*s*

South Pacific Enterprise has been written to mark the centenary of the Colonial Sugar Refining Company Limited, popularly known as C.S.R., and to tell the story of its activities, its position in the sugar industries of the South Pacific and the policies which have determined its organization and expansion.

The company was formed in 1855 after the failure of its two predecessors. From then until 1933 its growth and policy were controlled very largely by two men, Sir Edward Knox and E. W. Knox, father and son. Today it is a typical large and efficient joint-stock company.

Apart from the short historical section, the book deals with C.S.R. as it is today and in so doing gives considerable information about the whole of the sugar industry in Australia. It tells of the operation, management and ownership of the company and the part it plays in the community.

Various chapters, each written by an expert on the subject in question, deal with the different sections of C.S.R. activities which include raw sugar manufacture in Australia and in Fiji; sugar refining in Australia and New Zealand; sugar marketing; the manufacture and marketing of building materials such as insulation board, hardboard and wallboard; distilleries for making rum, ethyl alcohol, butyl alcohol and acetone; the owning and

operation of ocean-going vessels for the transportation of sugar and molasses; the manufacture of industrial chemicals such as acetic acid, cellulose acetate, moulding powders and vitamin C. Other activities include research and an agricultural advisory service. Last, but by no means least, is the organization of C.S.R. headquarters.

The book, including various appendices which are packed with information, is printed on good paper, is well bound and is profusely illustrated with excellent sketches, diagrams and photographs, many of which are in colour.

Throughout the book there runs a theme showing the justification for large scale capitalist enterprises in the world today, including the way in which they improve the standard of living of all the people and strengthen the economic structure of the whole country, particularly if they increase their capital and total output by ploughing back into their business part of their profit over a long period of years. This is precisely what C.S.R. has done.

Although it may not have been intended by the authors, the book provides an excellent example of how a company which originally started with a single sugar refinery may spread to all the other departments of the sugar industry, including sugar by-products. Several other examples of this are to be found throughout the world. On the other hand cane growers seldom become mill owners, refinery operators and manufacturers of sugar by-products. The reasons for this might well form the subject of an interesting economic and social study.—R.D.E.Y.

OBITUARY

Gwilym Arthur Jones, C.M.G., Dip. Agri.

Gwilym Arthur Jones, who died in Liverpool on 13 November 1957, was born in North Wales on 14 January 1887. He studied at Bangor University College and was awarded the Diploma of Agriculture. In 1909 he was appointed to the Imperial Department of Agriculture which at that time was the body responsible for agricultural education and research in Barbados, the Windward and the Leeward Colonies.

Its functions were taken over by the Imperial College of Tropical Agriculture when that institution came into being in 1922.

Jones's first substantive posting was to Dominica as Assistant Curator of the Botanic Garden. He spent the rest of his working career in the British West Indies. It was in Dominica that he learnt so much about the local crops and the methods of agriculture employed both by the peasants and the small landed proprietors. He was quick to spot weaknesses and to suggest improvements in crop production, but was wise enough to see that little advantage would accrue to the producers unless they could be persuaded to combine together for the grading and marketing of their produce. He was promoted to Chemist in the Dominica Agricultural Department in 1915.

After a short time he left Dominica to take up an appointment with the Ste Madeleine Sugar Company in Trinidad. He became adviser to the Company on matters connected with crop production in the field and his work led to many advances in cultivation and manuring. The large number of cane farmers who sold their cane to the factory also came under his direction and he was successful in getting higher deliveries of better cane by means of demonstration plots, personal exhortation and similar means. To this end he used all his powers of persuasion backed up by Celtic ' fire and fervour '.

In July 1929 he accepted the post of Assistant Commissioner of Agriculture at the Imperial College of Tropical Agriculture and in 1932 became Commissioner on the retirement of Professor H. A. Ballou. Jones remained at the College until 1938 and his work there earned him the C.M.G. As Commissioner of Agriculture his main duties were concerned with the Windward and Leeward Colonies. He was convinced that in order to improve the lot of the peasant proprietor and the small estate owner, organized buying, grading and marketing of produce would be essential if they were to be able to dispose of their produce profitably.

This meant an immense amount of propaganda and spadework entailing numerous meetings and conferences and endless tours up and down the Islands. Some of the results of his work may be mentioned. The arrowroot growers of St Vincent were encouraged to form their own association to grade and market the product with the result that this industry, which was rapidly becoming moribund, is now flourishing. Similarly the lime growers were formed into an association which insisted on definite standards and arranged for marketing through one channel. In a similar way the producers of Sea Island cotton were organized into an association, with a branch in London, to the great benefit of all concerned. The export of tomatoes,

bananas and other fruits to Canada was initiated and packing sheds started in Montserrat, St Lucia and other islands. Jones was also called in to advise on the new Land Settlement Schemes which had become a matter of policy between the wars.

When he left the College in 1938 to go to Jamaica as Director of Agriculture he could feel with truth that he had been able to accomplish much.

In Jamaica he found the times difficult owing to war conditions. The cessation of banana exports during the war had brought that industry to a very low state of efficiency and other export crops had been similarly affected. He endeavoured to cope with these problems and also started certain land settlement schemes and reorganized the Agricultural Department and its experimental farms. But Jamaica was in a state of turmoil at the time particularly politically and the long hours in the Legislative Council and the endless paper work finally undermined his health and he tendered his resignation in 1947. Jones continued to live in Jamaica and retired to the pretty little town of Mandeville in the central uplands of the Island.

After the death of his wife he continued to reside in Mandeville and one remembers visiting him there and noting the prominent position he had assumed in the local community and the regard in which he was held by all.

There are probably some of his former colleagues at the College who will remember him with affection and regard and who have pleasant recollections of the hospitality received from G. A. Jones and his wife.—G.E.

Recent Publications of The Imperial College of Tropical Agriculture

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Flora of Trinidad and Tobago: This Flora, which has been issued irregularly in parts since 1928, is a compilation of the work of many authors. The early parts, mainly by R. O. WILLIAMS, were edited by the Department of Agriculture of Trinidad and Tobago, but since the end of the 1939–45 war editing has been taken over by the Botany Department of the Imperial College. The Flora may be obtained either from the Department of Agriculture or from the Imperial College. The following parts have been published :

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These and other publications can be obtained from the Library and Publications Department, Imperial College of Tropical Agriculture, Trinidad.

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